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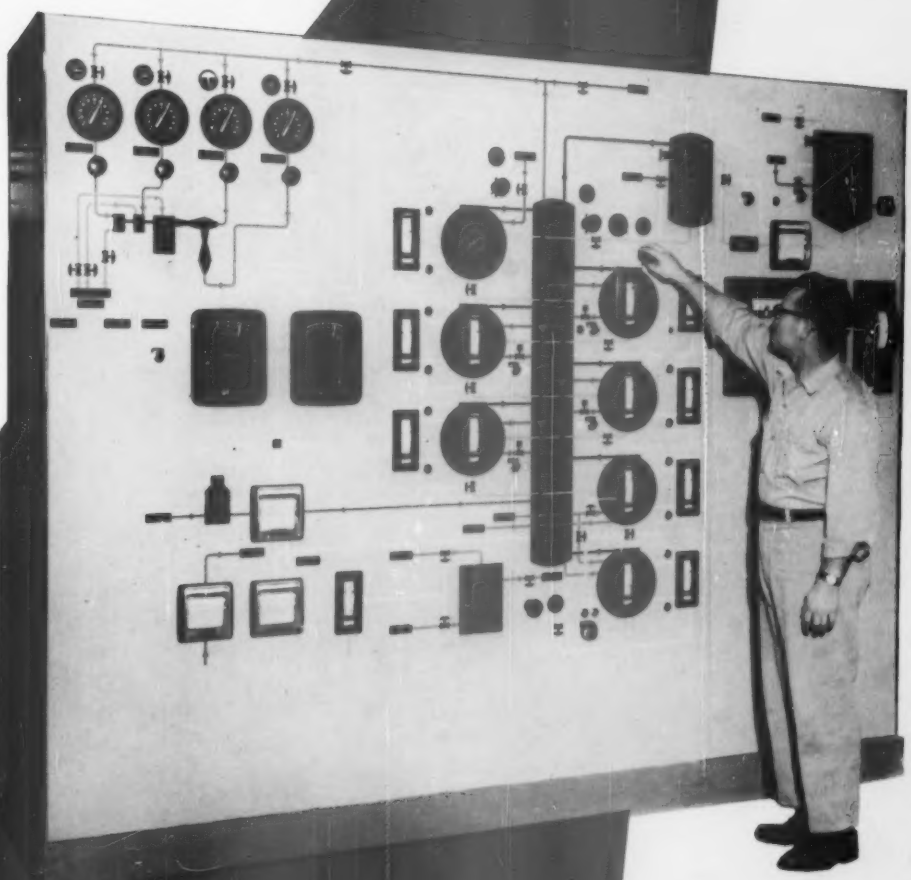
FT food technology



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By Donald J. Hanahan, *University of Washington, with chapters by* Frank R. N. Gurd, *Equitable Life Assurance Society of the United States, and* Irving Zabin, *University of California, Los Angeles*

This book is designed to serve as a review of the field over the past ten years, an introduction to lipide chemistry, and a general orientation and refresher for those currently working in this area. First of all it evaluates and documents the great progress in this fast-moving field, then it correlates the material with what has gone before. Chief emphasis is on the chemical nature of the lipides—mainly from mammalian soucres but applicable also to many other sources—and the difficulties one meets in establishing with any kind of certainty the structure and purity of lipides isolated from natural sources. *1960. 330 pages. $10.00.*

2. NUTRITIONAL EVALUATION OF FOOD PROCESSING

Edited by Robert S. Harris, *M.I.T., and the late* Harry Von Loesecke, *formerly of the U.S. Department of Agriculture.* This is the first book to review in a critical manner the effects of "processing" in the broadest sense, on the nutritional values of *all* groups of foods. The authors, all distinguished in their own fields of endeavor, take as their main point a study of the increases and decreases in nutrients and their availability for absorption, as foods pass through the many processes from growth to consumption, "from garden to gullet." *1960. Approx. 590 pages. Prob. $12.00.*

3. Principles of DAIRY CHEMISTRY

By Robert Jenness, *University of Minnesota, and* Stuart Patton, *Pennsylvania State University.* Written so that it provides a deep understanding (as opposed to offering a volume of reference data) of milk and its constituents, their chemistry, their interactions under various conditions, and what all the different factors mean to the production and storage of dairy products. This treatment includes a chapter on nutrition in relation to milk. *1959. 446 pages. $8.75.*

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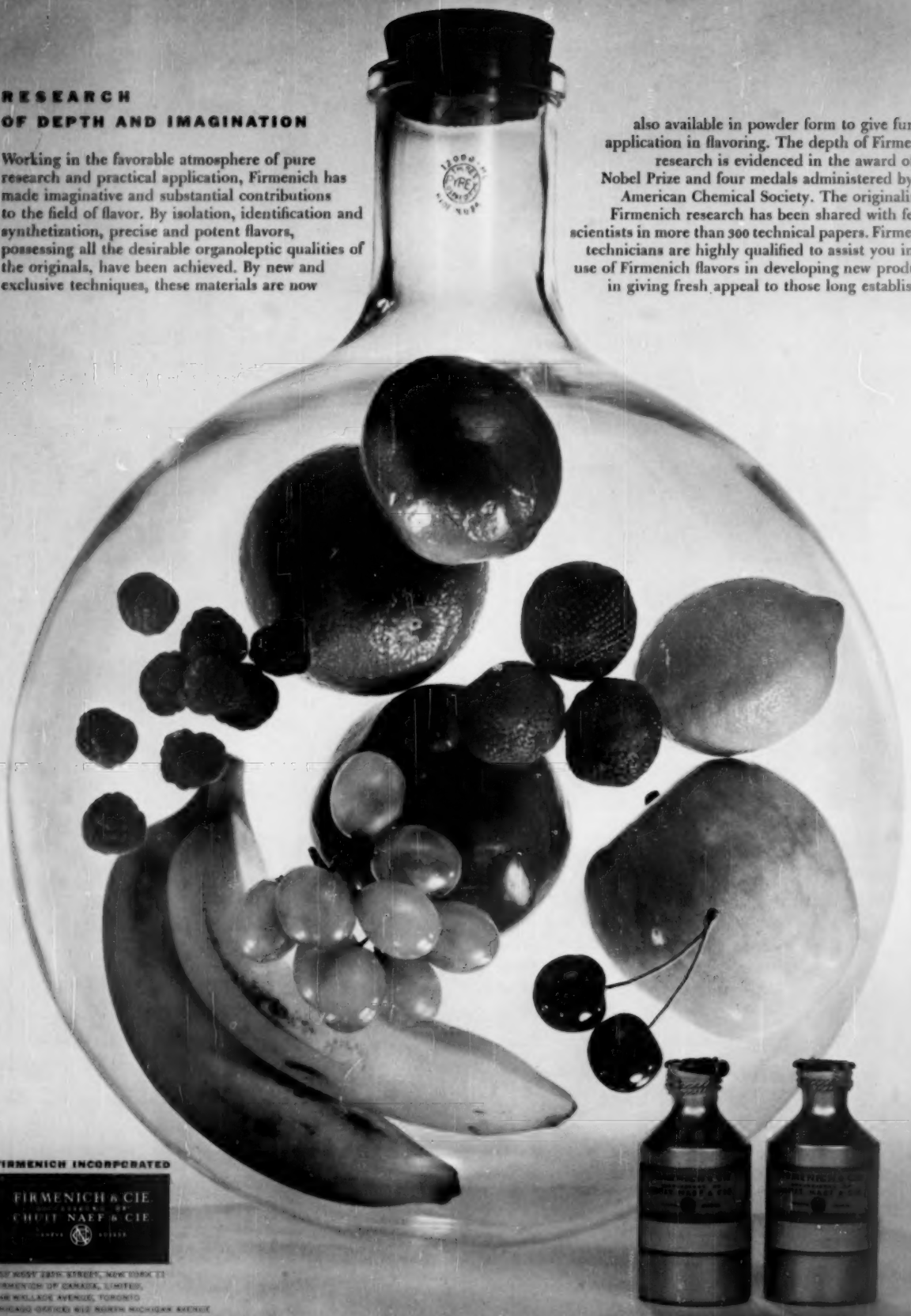

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IN THIS ISSUE—

TECHNICAL ARTICLES IN BRIEF

Quality evaluation *Pork*

Consumer quality of selected muscles of raw and cooked pork. Olive M. Batcher and Elsie H. Dawson.

The quality of meat is influenced by many interrelated factors, and the complex problem of ascertaining the tenderness and flavor of cooked meat from the characteristics of raw meat needs to be evaluated. Variations in the quality of pork loin have been reported, but little is known of the comparative quality of various pork muscles. This investigation reported in this article was made (1) to compare the quality of cooked pork from carcasses of hogs varying in fatness, (2) to determine the variations which might be encountered among raw and cooked pork muscles, and (3) to ascertain which muscles might be used as indices to the qualities of hog carcasses varying in fatness. The degree of marbling in the raw *longissimus dorsi* muscle between the 10th and 11th ribs shows promise as a means of predicting the tenderness and juiciness of cooked loin and ham cuts of pork. Greater variations in fat content, color, and tenderness were noted among muscles from some carcasses than from others. It would appear that more than one muscle should be used to evaluate the quality of a cut because muscles vary so greatly. (See page 69).

Meat research *Water retention, beef*

Factors affecting the water retention of beef. II. Variation in some pH determinants among eight muscles C. E. Swift, M. D. Berman, and C. Lockett.

An important property of meat is its capacity to retain water or juice. This ability directly affects results in meat cookery, meat storage, and the manufacture of meat products. Ultimate object of the present research is to develop a basis for controlling or, when desired, enhancing the capacity. A comparative study of the glycogen and protein content, pH, and buffering capacity of eight different muscles from each of seven bovine animals was conducted to investigate factors contributing to a pattern of differences in the ultimate pH values of the muscles. Results show that both glycogen and buffering capacity varied considerably among the muscles. Variation of both glycogen and buffering capacity followed patterns with regard to pH, water retention, and other properties. A statistically significant positive correlation was obtained between glycogen and protein content. Since all eight muscles contained residual glycogen when the ultimate pH was attained, the relatively high characteristic pH of certain muscles could not be simply attributed to lack of glycogen. The content of residual glycogen was found to be largest in muscles attaining the lowest ultimate pH values. The same muscles originally contained the largest glycogen stores. Variation of concentrations of glycogen could be closely correlated with rates of glycolysis, which affect the total glycolysis that occurred. Data are presented indicating that pH decrease and disappearance of ATP contributed to the arrest of glycolysis, as is consistent with accepted concepts of the glycolytic process. A high significant negative correlation was found between buffering capacity and pH. Buffering capacity tended to be largest in muscles of low pH. Consequently, buffering varied so as to minimize the pH differences anticipated from the amount of glycolysis occurring in different muscles. An explanation of the observed variation in the pH of the series of muscles is advanced; namely, that ultimate pH varies with the amount of glycolysis occuring prior to ATP disappearance and that the amount of glycolysis occurring during this interval is affected by variations in rates. This variation in rates has been correlated with differences in the amounts of original glycogen stored, but does not preclude variations in the capacity of the glycolytic enzyme systems in the muscles. (See page 74).

Stability *Frozen cakes*

Effect of temperature on stability of frozen cakes. James W. Pence and Marjorie Heid.

Cakes are well adapted to preservation by freezing, and the practice is widely used by commercial bakers and homemakers. Several reports attest to the relative tolerance that cakes have toward variations in freezing and defrosting practices that are so important with bread and related items. The present paper is concerned with time periods required for detectable organoleptic changes to occur in each of 5 kinds of commercial cakes held at different refrigerated or subfreezing temperatures. Texture changes in the frozen cakes were generally detected before changes in flavor. Principal texture changes were loss of original crumb resiliency and increases in crumbliness and harshness. Each type of cake exhibited texture

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changes of a somewhat characteristic nature. Flavor declined gradually to yield increasingly bland products. No characterizable stale or off-flavors were encountered. Yellow and chocolate layer cakes exhibited relatively good stability at 10° F and greatly improved stability at 0° F. However, little gain in stability was obtained at −10° and −30° F. Layer cakes seemed to soften and become more moist at 0° F or below. This apparent softening eventually deteriorated into an unacceptable gumminess or pastiness. Layer cakes were by far the most stable of the cakes studied. Pound cakes at temperatures of 0° F and below very rapidly developed differences in texture but the initial loss of resiliency and increased firmness later appeared to become overshadowed by increased tenderness as the cake became more crumbly. All types of cake showed highly significant differences from freshly baked cakes within four weeks at 0°F. Even after significant changes had occurred in the frozen cakes, however, their quality was still quite good. In all cases, they were superior to day-old unfrozen cakes. (See page 80).

New process — *Smitherm method of hot fat cooking*

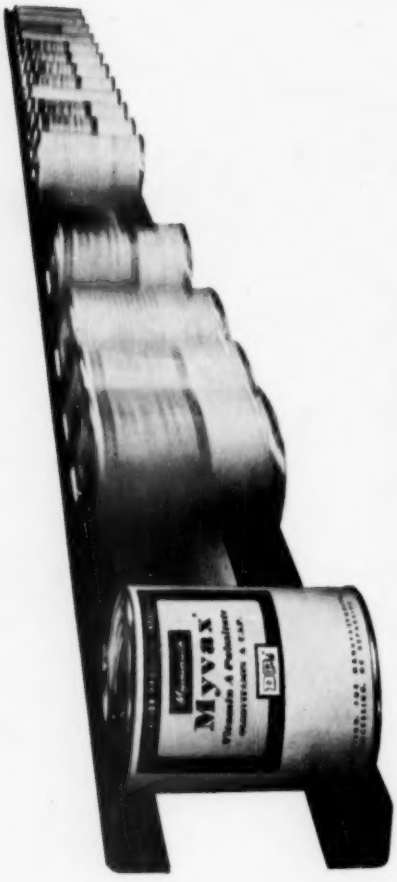
Heat transfer in hot fat cooking. Horace L. Smith, Jr.

Many food products are cooked or processed in hot fat. This process, sometimes termed "deep fat cooking," usually has three coincidental effects: (1) chemical changes that occur while the product is being converted from its natural raw state to a cooked product; (2) evaporation of moisture from the product, and (3) absorption of fat into the product, which usually adds a desirable flavor. The relative importance of these three separate functions varies with the product. The Smitherm method of indirect heating of cooking fats was developed to eliminate defects in the conventional method—e.g., destructive high temperatures in the film of fat in contact with the heating surface, low thermal efficiency, lack of temperature control. Summary of the advantages of the Smitherm indirect method are: (1) substantial reduction in heat damage to the cooking fat due to the fact that the fat cannot come in contact with a high temperature surface, (2) product improvement due to reduced rate of increase of free fatty acids, therefore adding shelf life to the product, (3) precise temperature control and means for accurately controlling both the inlet and the outlet temperature of the fat regardless of fluctuations in product load, (4) substantial fuel savings, (5) multi-cooker operations, (6) safety and comfort, (7) increased capacity. It has been shown that at least 50% more production can be obtained from the same size cooking kettle compared to the maximum production obtained with direct fire cooking. (See page 84).

Technology of handling — *Hot vended canned foods*

Problems in the Preparation and handling of hot vended canned foods. G. T. Peterson, J. F. Fox, and L. E. Martin.

The preparation and handling of hot vended canned foods present problems of direct concern to the canning industry and to the acceptance of such canned foods in general. Broadly these include: (1) *bacteriological* aspects of preparation, storage and handling of hot vended canned foods; (2) effect of high temperature storage in vending



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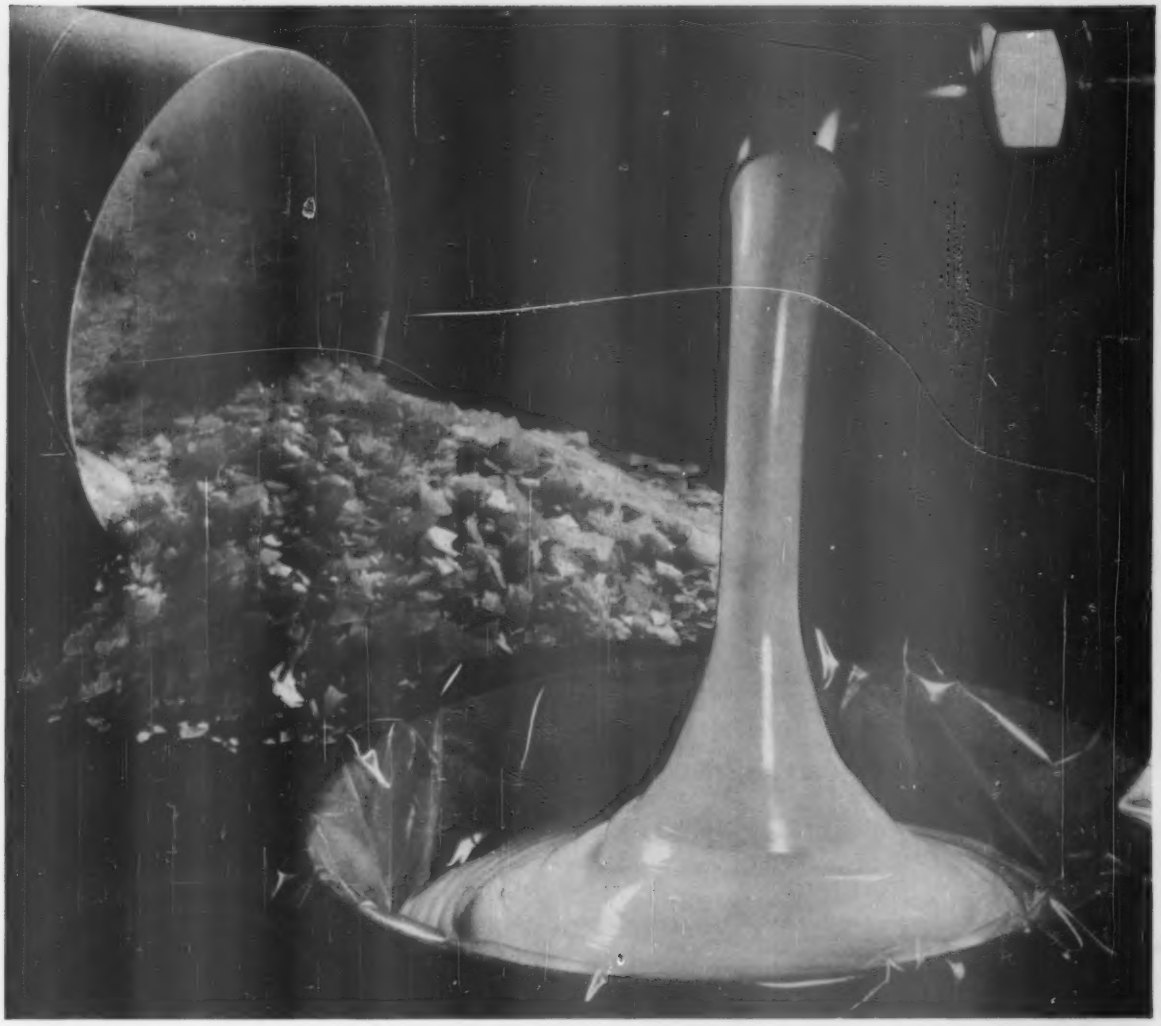

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machines on *product quality;* and finally (3) *consumer acceptance* of hot vended canned foods. Aspects of these various problems are discussed. Maintenance of product quality during high temperature storage in the vending machines is of major concern to both the processor and vendor. The processor must determine acceptable quality storage life for his products and reformulate if necessary in order to maintain quality levels comparable to other methods of handling and serving foods. The food service industry also recognizes some problems in this type of merchandising — particularly, the sanitation of vending equipment and can openers. Sanitary maintenance of equipment and frequent changing of can openers on a regular schedule have done much to alleviate this problem. Consumer acceptance of both the product and method of consuming (direct from cans) is a joint problem of the food service industry and food processors. It is strongly recommended that food processors do everything possible to develop a wider variety of products as well as to improve existing products to withstand high temperature storage and retain high quality to help overcome "lower quality" and "no variety" objections or complaints. (See page 89).

Irradiation — *Applied to cured bacon*

The influence of low level gamma irradiation, antibiotic treatment, storage temperature and vacuum packaging on flavor and bacterial changes in cured bacon. W. L. Brown and M. L. Schmucker.

Combination methods of preservation for extending the shelf life of meat products appear to offer numerous advantages over the use of a single method. The objectives of the present study were to evaluate storage stability and bacterial changes in cured bacon subjected to different handling and storage conditions after slicing. Using bacterial changes and flavor ratings by a trained panel as criteria of product acceptability it was established that holding temperatures, method of packaging, irradiation and addition of an antibiotic each had its effect on the quality of sliced bacon. Results indicated that low storage temperatures (28–32° F) and vacuum packaging were slightly more effective in maintaining an acceptable product than any of the other treatments: (See page 92).

Curing of meat — *Effect of sugar*

The effect of sugar on the flavor and color of smoked hams. Franklin Mills, C. Edith Weir, and G. D. Wilson.

Sugar has been employed in the curing of meat because, presumably, it has value in (1) enhancement or development of flavor, (2) development and protection of the cured meat color and (3) retardation of a putrefactive type of spoilage. This article reports a study on the effect of sugar on the color development and retention and flavor of hams cured three to seven days. Between 0.50–0.75% sugar appears to be required to reach the threshhold level for detection of sweetness in hams. This would correspond to 50–75 lb sugar per 100 gal of pump pickle. This is probably higher than the concentration of sugar usually employed in commercial practice. Color analysis indicates no effect of sugar upon color production or stability. An effect upon the amount of color development due to length of cure was observed. This would indicate that the effects of sucrose upon color development and retention noted by other workers on long cure hams are not of significance when curing is limited to a few days. Bacterial flora did not appear to be affected by the treatment. If a sweetening agent is desired in rapidly cured hams, sucrose, dextrose, or a cycylamate appear to be interchangeable. (See page 94).

Antibiotics — *Control of beef during aging*

Efficacy of oxytetracycline for aging beef. R. B. Sleeth and H. D. Naumann.

This investigation is concerned with the effect of antemortem injection of an aqueous antibiotic (OTC) solution to control surface and internal microbial growth during aging of beef. Findings are: The tail, as a site of antemortem antibiotic injection, offers greater possibilities than any other injection site previously utilized. Adequate product protection from external sliming and internal spoilage was provided beef that received an ante-mortem intramuscular injection of 0.80 mg/lb of OTC and was aged under elevated temperatures and ultraviolet radiation or a combination external spray consisting of 20 ppm OTC and 20 ppm nystatin. However, an undesirable appearance developed on the surface of the product due to ultraviolet radiation. By utilizing the external spray, the normal appearance of the product surface was maintained during the aging process. Total surface bacteria, coliform, yeast, and mold counts were negligible after the carcasses were washed and sprayed with OTC and nystatin prior to aging. Counts increased during the aging period until processed but were not extensive enough to cause sliming and spoilage. Total bacteriological counts of the synovial fluid, excised popliteal lymph node and the *semimembranosus* increased slightly during aging but were not significant. The concentration of OTC in various beef tissues was affected by the time lapse between injection and slaughter. The OTC concentration in the blood decreased with time; concentration in other tissues, except kidney and spleen, increased and had not plateaued at the end of six hours. Residual antibiotic in the kidney decreased after two hours. No OTC was found in the spleen. Under conditions of this study, product protection did not appear to be a function of time the OTC was injected ante-mortem. It is significant to note the adequate protection received when animals were injected only 30 minutes prior to slaughter. Aging temperature did not influence the dissipation rate of the antibiotic in the muscle tissue. (See page 98).

Additives — *To reduce cohesion in rice*

Use of emulsifiers and emulsified oils to reduce cohesion in canned white rice. R. E. Ferrel, E. B. Kester, and James W. Pence.

Short-grain or pearl rices, produced principally in the western states, normally are quite sticky as well as cohesive when cooked. The sticky character was largely overcome by a canning process developed at this USDA laboratory. An undesirable degree of cohesiveness remained, however, making the rice difficult to remove from the container and to separate into individual kernels. This report is concerned with treatment of the rice with surface-active materials and vegetable-oil emulsions to reduce cohesion between kernels without affecting other properties of canned rice. A rinse treatment with dilute

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vegetable oil emulsions or dilute dispersions of certain surface-active agents during canning proved to reduce markedly the cohesion. Cold storage of the product after canning was also beneficial. Neither the type nor concentration of emulsifier in the emulsion influenced significantly the degree of cohesion in treated products. Emulsifiers differed in their effect upon cohesion when used alone, but no correlation with their type or structure was evident. Reduction of cohesion in the rice was directly related to the logarithm of oil concentration in the emulsions. Amount of oil taken up by the rice reflected the concentration of oil in the emulsion but barely exceeded 1.0% even at a level of 15% oil in the rinse. When oil level was below 5% in the rinse, a taste panel could not reliably distinguish between treated and untreated rice. No change in organoleptic properties appeared in treated rice after 19 weeks of holding at 100° F. Small though significant differences in cohesiveness were found among treated samples of milled rice of different age and crop year. (See page 102).

New product — *Comminuted orange*

Comminuted orange: a novel process for its manufacture. J. B. S. Braverman and Aaron Levi.

Since citrus peels contain more than twice the amount of ascorbic acid than does the juice of the endocarpium and all of the essential oil is incorporated in the flavedo, some producers of citrus products have tried to make use of this resource. One way is to convert the whole of the citrus fruit into an edible product. "Comminuted orange" is a recently coined term introduced into the trade dealing with citrus products. It means transforming citrus fruit into paste of more or less fine texture by means of some sort of disintegration. Apart from isolated articles and news items in industry journals and a few patents, practically nothing has been published on this subject. Most of the methods of manufacture at present used for comminuting citrus fruit are based on the following main steps: either whole citrus fruits, or the peel alone, or various proportions of juice, rag and peel are mechanically disintegrated and milled to a fine colloidal paste using suitable milling equipment. In some cases the milling is preceded by cooking the peel in double jacketed stainless steel tanks in order to soften it before comminution. What is usually required of a good product seems to be: (a) practical sterility of the product, (b) proper colloidal consistency, (c) retention of vitamin C, (d) inactivation of pectolytic enzymes, (e) good keeping qualities. Existing processes of manufacture seem to have distinct deficiencies and leave much to be desired of the final product. The novel process of manufacture proposed in this article has been fully tried out on both a laboratory and a pilot-plant scale. It consists in heating whole oranges in an Henze apparatus and blowing out the contents, and subsequently finishing and milling the final product. Several important qualities in the final product have been attained by this process: complete sterility of the product, disintegration without mechanical means, and finally inactivation of enzymes. The keeping qualities of the products are described. (See page 106).

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Quality tests — *Freshly shucked, refrigerated oysters*

An evaluation of the indole and trimethylamine tests for oyster quality. Donald Lartigue, Arthur F. Novak, and Ernest A. Fieger.

The experiments herewith reported were designed to: (1) ascertain the applicability of the indole and trimethylamine tests for oysters, modifying them when necessary, (2) evaluate these tests as indices of oyster quality by comparing them to bacterial counts and organoleptic ratings at various stages of oyster decomposition, (3) determine the effect of CTC as a preservative for oysters, and (4) the effect of CTC on these tests and on the spoilage mechanisms of oysters as evidenced by indole and trimethylamine formation. Some modifications were made which were necessary for adapting these tests to oysters. These modified tests were found to be accurate and reproducible. Both are sensitive and capable of detecting microgram quantities of the compounds. These determinations along with bacterial counts, liquid measurements, and organoleptic ratings were employed in oyster quality tests, and their value as indices of oyster spoilage was determined. Since indole and TMA concentrations showed no definite pattern during storage, however, these tests are not recommended for assessment of oyster quality. Bacterial counts and liquid measurements closely parallel organoleptic ratings. Spoilage was usually evident from the eighteenth to the twentieth day of storage. The oysters at this time had bacterial counts of about 10 million per gram, and had decreased in weight by about 13% due to the loss of fluid from the meats. The effects of CTC on these tests and on extending the storage life of oysters were also investigated. The antibiotic did not interfere with the tests, nor did it suppress the formation of indole and TMA. It did limit the bac-

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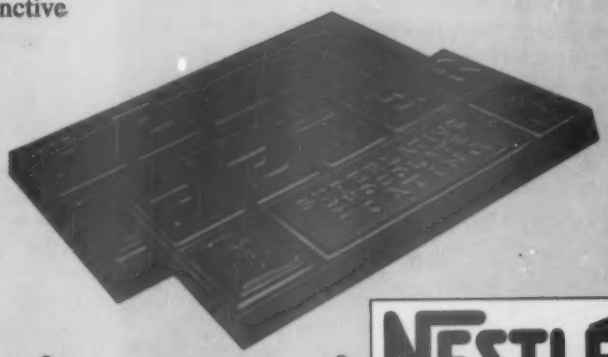

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terial count, and the development of off-odors. (See page 109).

Antimicrobial agents — *Applied to high-moisture dried fruits*

Preservative effect of some antimicrobial agents on high-moisture dried fruits. F. S. Nury, M. W. Miller and J. E. Brekke.

In recent years, the dried fruit industry of California has increased the moisture content of a substantial portion of the total pack of dried prunes and dried figs. It is likely that the trend to higher-moisture products will embrace other dried fruits, particularly raisins. There is a definite consumer demand for high-moisture dried fruits. These products are very tender, moist, and palatable and can be eaten out of hand. Although these fruits are already a part of the general trend toward ready-to-eat and convenience foods, certain problems of preservation require attention. Several preservatives for high-moisture prunes were tested by incubating treated and inoculated samples. Potassium sorbate and propylene oxide were found to be the most effective. Calcium propionate, dehydroacetic acid, and vitamin K_5 were shown to be considerably inferior under the conditions of these experiments. Potassium sorbate was found to have a residual effect in that the treated prunes did not spoil in open packages. (See page 113).

Low temperature storage — *Pie doughs*

A note on the effect of various temperatures on some characteristics of pie doughs. Earl W. Cole and D. K. Mecham.

These experiments indicate that fat hydrolysis and increases in total reducing substances occur in pie doughs held at low temperatures, but at temperatures of 19° F or lower, these changes occur at a very slow rate. The results with "shorts" suggest that doughs prepared from flour fractions having marked variation in composition undergo these chemical changes to about the same degree of magnitude. Changes in doughs are so slow compared to those that can be expected in pie fillings as to suggest they need be of little concern in commercial storage practice. (See page 115).

Improvement in measuring device — *Gelometer*

Transistorized bloom gelometer. Ralph E. Schachat and Anthony Nacci.

The "bloom gelometer," in use for a number of years for gel strength measurements of gelatin and other colloidal gel systems, has remained essentially unchanged. In its present form, the device has certain defects. A major fault is that in spite of the relay, a sizeable current flows through the silver plated contacts. This causes burning and pitting at the contact surfaces which must be then frequently polished and the gap readjusted to exactly 4 mm. If the contacts are not properly cared for, loss of sensitivity precision, and accuracy may result. This article reports a modification; namely reducing the current passing through these contacts to a negligible value. This was done by using a transistor amplifier circuit. Once the contacts are polished and adjusted to 4 mm, they do not have to be adjusted for a long period of time. Pitting is eliminated, and, even if the contacts become

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dirty through slow deposition of a film of dust, the extreme sensitivity of the transistor circuit continues to activate the relay and chute in the normal manner. A transistor relay amplifier was tried and found to operate quite satisfactorily for this application. (See page 117).

Effect of silicones *On cake volume*

The effect of several silicones on volume of yellow cakes. W. J. Stadelman and Grace Bennett.

The effect of seven silicone oils on yellow cakes prepared with institutional and consumer-type cake mixes was determined. Of the silicones tested, none resulted in serious diminution of cake volume when included in the batter at 0.1 or 1.0 ppm. At a 10 ppm level, some of the silicone oils resulted in a reduction in volume of yellow cakes by as much as 20%. Others of the silicones used had no significant effect on volume of yellow cakes even when 10 ppm of the silicone was incorporated into the batter. (See page 119).

Pacific Rim Food Conference to Evaluate New Import and Export Foods

Ralph M. Heinicke
Program Committee,
Hawaii Section, IFT

MEMBERS ATTENDING the 1960 Pacific Rim Food Conference, sponsored by the Institute of Food Technologists and programmed by the Hawaiian IFT, have a unique opportunity to evaluate for themselves some of the challenging new foods and food combinations which might be purchased from the Asian countries. They will also have an opportunity to evaluate the export potential of certain food products which could be produced in the temperate countries. These trade opportunities are, to a very large extent, undeveloped. One of the primary aims of this conference is to assemble American, Australian and Asian food technologists to exchange information, to explore the potential and actually to make the beginnings of a new exchange of foods.

The conference will consist of two parts, a series of field trips to various tropical food plantations on Oahu and Hawaii and a two-day session of discussion and panel talks.

IFT members attending the 20th Annual Meeting of the Institute in San Francisco, May 15–19, are urged to keep in mind the dates of the Pacific Rim Conference, May 19–25 (or May 29 if you take advantage of the longer tour).

FIELD TRIPS AN IMPORTANT FEATURE

The field trips will give mainland food technologists a better understanding of tropical agriculture and processing and packaging of tropical fruits. On the slopes above Kona we shall visit the record yielding coffee plantations which produce one of the aromatic coffee beans used in the better blends. On the Puna coast of Hawaii we shall inspect the papaya and passion fruit groves, two fruits which could be used in combination with mainland fruits. Not far from Hilo we shall examine the new acerola plantings and the macadamia nut orchards growing in what looks like raw lava. Special tours and programs are planned for the wives.

AN OPPORTUNITY TO OBTAIN INSIGHT INTO PACIFIC RIM FOOD NEEDS AND RESOURCES

Two technical sessions will run concurrently. One will cover primarily meats and grain products grown in America, Australia and New Zealand which might make valuable additions to the Asian diet. The other will cover primarily tropical fruits, vegetables, and fish which might be developed into an export item for the U. S., Australian and Canadian markets. In these sessions samples of fresh, frozen, and processed foods will be available for inspection and tasting. Members of the panels will present information on the vitamin content, food value, processing problems and availability of these foods.

The final session will be a plenary session covering the problems of transportation, tariff and quarantine barriers, and types of food processing development which could take place.

This conference is in a way a renewal and an extension of the Pan Pacific Conference held in Honolulu in 1925. At that conference members of various Asian countries, of the West Coast states and of Hawaii met in Honolulu to discuss agricultural production problems. At the 1960 conference we similarly aim to bring together in a spirit of cooperation members of the American, Australian and Asian countries, to explore projects which can benefit all groups. The members of the National Program Committee and our Hawaii Program Committee believe that the exploration of new trade potentials between our two groups of countries is a project which is not only timely and interesting but which is also extremely important. It could strengthen the cultural and economic ties between our two groups of countries and it could also be a source of profit for both groups.

We hope that many members of the IFT can attend this conference. We hope that they will not only enjoy the beauty and hospitality of the Islands but also feel the tremendous challenge of the aim of this conference and do their part to make it come true.

help IFT give away $22,000!

YOUR COOPERATION is requested in helping give away $22,000!

Your Institute is responsible for this pleasant task each year, and you can help.

Consider now, who you feel should receive these funds. Only thirteen persons in the United States and Canada will be selected.

Purpose of expenditure of these monies is to encourage:

—graduate work in the field of food science
—graduate work in the field of science with particular emphasis on its relation to foods
—graduate work in the fields of food science and food technology
—deserving and outstanding students to take undergraduate work leading to a Bachelor's Degree in Food Technology, Food Engineering or Food Science.

Anyone Can Help

Furtherance of educational standards in the United States is one reason the IFT administers Fellowships, Scholarships, and Awards. You, member or not, can help in this administration by bringing these awards to the attention of students who you feel may qualify. Support your organization as it attempts to do its part in maintaining and raising U. S. educational standards.

A $1000 Florasynth Fellowship is administered each year. It is awarded to a B.Sc. candidate who has a better than average scholastic record, and who is engaged or plans to engage in graduate work for an advanced degree in one of the fields listed above. In addition, the awardee shall receive an engrossed plaque.

IFT'ers Important

Each of the other twelve individuals receiving an award must make his own application. This is where Institute members are extremely important. Try to ensure that all qualified students in your area are aware of the possibility of receiving financial aid toward their education. Most members probably realize the significance of such aid to a student and potential member of the Institute.

Twelve thousand dollars is donated annually by the General Foods Fund, Inc., in the form of three General Foods Fellowships at $4,000 each, with an engrossed plaque to each awardee. Fellowships will be awarded to deserving and outstanding United States or Canadian citizens, engaged in senior undergraduate or graduate work in recognized educational or research institutions in the United States of America or Canada, and who propose to pursue graduate work in basic or applied chemistry, chemical engineering or related sciences, which may involve new physical or other procedures, directed to extending or improving knowledge in some phase of food conservation, food production or food processing, rather than primarily for research in the fields of nutrition, bacteriology or analytical chemistry.

Tell Students This . . .

Tell students they are responsible for submitting their own letter-form application in applying for the General Foods Fellowships.

The applicant shall have an approved plan of research and acceptance thereof by the Graduate School of the institution in which he proposes to hold the Fellowship. In presenting his application, the applicant should indicate his definite intentions on his word as a gentleman, to carry through with his approved research plan for the period of time for which the award is made insofar as it is humanly possible.

The other Fellowship, of which your Institute is administrator and donor, is the Samuel Cate Prescott Fellowship. An engrossed plaque and $1,000 is awarded annually to the student selected, who meets the following general conditions: the award will be made annually to an outstanding young man or woman of any nationality engaged in senior undergraduate or first year graduate work in the general field of food science and food technology, at a recognized educational or research institution in the United States or Canada.

Again the Institute relies on its members to disseminate information to students that they are responsible for submitting applications.

DEADLINE for receipt of all Fellowship nominations and applications will be strictly adhered to this year. The date is March 1, 1960.

Eight thousand dollars worth of undergraduate awards and scholarships valued at one thousand dollars each, will be made this year, with Gerber Baby Foods Fund, Inc. donating six. Dodge and Olcott, Inc. will donate one such scholarship, as will the F. Ritter & Co. Accompanying these awards will be an engrossed plaque for each awardee.

. . . and This

Qualifications for each of the undergraduate awards and scholarships are similar, viz.: an applicant to qualify must have satisfactorily completed, prior to the effective date of the award, two full years of college work that will adequately prepare a student to complete the Junior and Senior years of a Food Technology course that is the equivalent of the model curriculum approved by the Institute of Food Technologists (see FOOD TECHNOLOGY, Vol. 12, No. 9, 1958). Candidates will be judged on over-all ability including scholarship, personality, extra curricular activities, social adjustment, character, etc.

So beat the deadline, March 1, 1960, by which time all applications and nominations for all awards must be received. Submit to Executive Secretary, Institute of Food Technologists, 176 W. Adams Street, Chicago 3, Illinois, along with any questions or correspondence.

Consumer Quality of Selected Muscles of Raw and Cooked Pork

Olive M. Batcher and Elsie H. Dawson

Human Nutrition Research Division, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

(Manuscript received May 21, 1959)

THE QUALITY OF MEAT is influenced by many interrelated factors, and the complex problem of ascertaining the tenderness and flavor of cooked meat from the characteristics of raw meat needs to be evaluated. Variations in the quality of pork loin have been reported *(3, 7, 8, 10, 11, 12, 14)*, but little is known of the comparative quality of various pork muscles. This investigation was made (a) to compare the quality of cooked pork from carcasses of hogs varying in fatness, (b) to determine the variations which might be encountered among raw and cooked pork muscles, and (c) to ascertain which muscles might be used as indices to the qualities of hog carcasses varying in fatness. Quality measurements were made on the *longissimus dorsi* (LD) muscle in the pork rib and loin cuts, and on the five largest muscles in shank and butt halves of fresh ham —the *semitendinosus* (ST), *semimembranosus* (SM), *adductor* (AD), *biceps femoris* (BF), and *rectus femoris* (RF) muscles.

MATERIALS AND METHODS

Ham and loin cuts from 12 gilt hogs of known history were obtained from the Animal Husbandry Research Division, Beltsville, Maryland. The hogs came from an experiment in progress on selection for high and low backfat thickness within each of 2 breeds of hogs. They were slaughtered when they reached 225 pounds live weight. The age of animals at time of slaughter was 6.3 to 8.5 months and the cold carcass weights were from 170 to 183 pounds. Carcass grades ranged from U. S. No. 1 to U. S. No. 3, and backfat thickness ranged from 1.2 to 2.0 inches.

Carcasses were chilled at 34 to 38° F (1 to 3° C). Within 7 days after slaughter, the carcasses were cut into wholesale and retail cuts and trimmed of excess fat. The loin was cut between the 10th and 11th ribs, making an 8-rib roast (rib end), and a loin roast (loin end). The shank and butt halves of the trimmed ham were separated at the aitch bone to form 2 cuts. All cuts were packaged in Cry-o-vac bags (vinylidene copolymer), frozen at −5° F (−20° C) and held in freezer storage for 2 to 5 months until all hogs were slaughtered and cuts could be randomized for the quality investigations. Some of the cuts from the 12 hogs were used for nutritive value analyses which will be reported elsewhere.

The frozen cuts were thawed in the wrappers approximately 24 hr, partially at room temperature (22° C) and the remaining time in the refrigerator (36 to 38° F or 2 to 4° C). The thawed cuts were roasted fat side up on racks in open aluminum pans in a 325° F (163° C) oven to an internal temperature of 185° F (85° C). This cooking method is commonly used by consumers for preparing pork roasts. After cooking, the muscles were dissected from the cuts and external fat surrounding the muscle was removed. The muscle was then weighed and sampled for shear, color, fat and moisture content, and palatability determinations. The same physical and chemical measurements were made on comparable muscles from raw cuts.

Marbling score. The marbling score based on the intermingling of the fat with the lean was made on a 5-point rating scale as follows: 5-abundant, 3-moderate, 1-slight. The marbling score of a cross section of the *longissimus dorsi* muscle was determined between the 10th and 11th rib. The series of pictures in Figure 1 shows the range that was encountered in cross sections of the *longissimus dorsi* muscle of the carcasses included in this investigation.

Tenderness. Tenderness of the muscles was measured objectively with a Lee-Kramer shear press, a modification of an instrument developed at the University of Maryland to measure

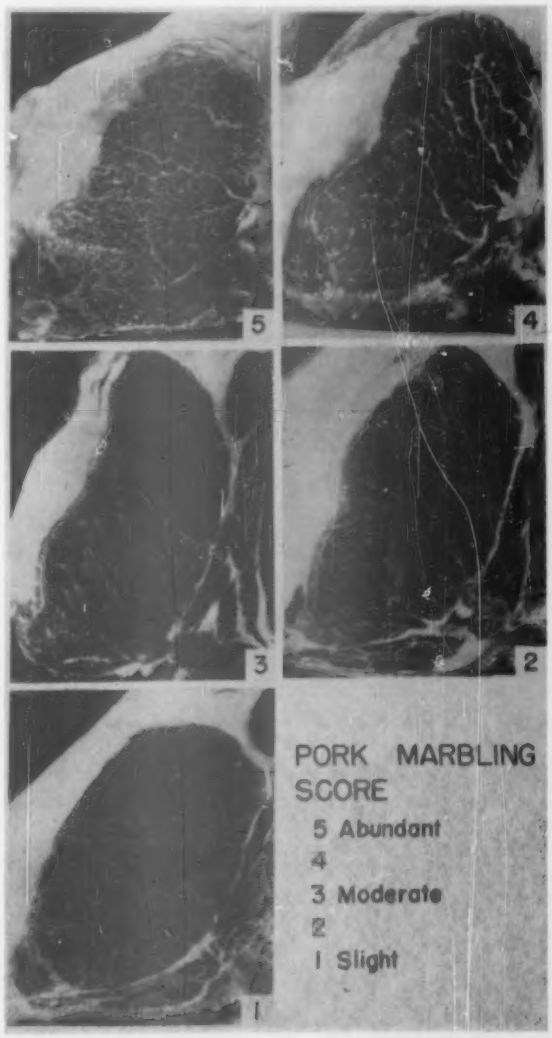

Figure 1. Marbling scores for raw fresh pork taken between the 10th and 11th rib of the longissimus dorsi muscle.

the tenderness of fruits and vegetables *(9)*. The instrument measures the pounds force required to shear, under a constant speed, a standard volume and weight of material. A cell (1⅝ in x ⅞ in x 1 in) which held a 20-g piece of meat was used. Measurements were made of the force required to shear across the grain of the muscle. A low shear value indicates very tender meat.

Intramuscular fat and moisture. Intramuscular fat and moisture contents were determined by standard AOAC methods *(1)*, using petroleum ether for extraction of the fat and drying with heat in vacuo for moisture, on aliquots of raw and cooked muscles.

Color. For the objective measurement of color, a Gardner Color Difference meter was standardized with an enameled tile *(6)*. For the raw samples a dark red tile, the approximate color of the meat, was used: $L = 24.6$, $a_L = 18.3$, and $b_L = 5.6$. For the cooked samples, a grey-white tile was used: $L = 84.4$, $a_L = -0.9$, and $b_L = 10.1$. With both tiles, the L system of Hunter values was used: L = lightness; a_L = redness when plus, greyness when zero, and greenness when minus; b_L = yellowness when plus, greyness when zero, and blueness when minus. The greatest variation in the Hunter values of the raw or cooked cuts was found to be in lightness. For this reason only the L values have been included in this report.

The small aperture and small clear glass cells (2 inches in diameter and 1 inch high) were used for all color determinations. For each set of readings, a cross section of the muscle ½ in thick was placed in the cell. The cell was rotated quarter turns, making 4 readings which were averaged.

Panel scoring. A trained 4-member panel rated the palatability of the cooked fresh pork muscles in terms of juiciness, tenderness, flavor, and general acceptability. The numerical scale and descriptions used by the panel for rating the quality characteristics of pork muscles are shown in Table 1.

Statistical design and analysis of the data. Cuts were tested according to randomized block designs *(4)* in which cuts from a meat-type and a fat-type hog were tested at any one session. Different randomizations were used for each of the 4 types of cuts (rib, loin, shank and butt halves of ham), raw or cooked. The method of analysis of variance and test procedures for multiple comparisons among means *(5)* were applied to the data. Standard deviations were calculated to indicate the variation among the carcasses in each quality characteristic of a muscle. The test difference is the minimum difference necessary for significance between the means from any two muscles at the 5% level. Linear correlation coefficients between various quality factors also were computed *(12)*.

TABLE 1

Descriptions used by panel for rating palatability characteristics of cooked pork

Numerical scale	Tenderness	Juiciness	Flavor[1]	General acceptability
9	Very tender	Juicy	Very full, rich, characteristic	Very good
7	Slightly less tender	Slightly less juicy	Full, characteristic	Good
5	Moderately tender	Moderately juicy	Moderately full	Fair
3	Slightly tough	Slightly dry	Slightly weak	Poor
1	Very tough	Very dry	Lacking or masked	Very poor

[1] If natural flavor was masked by off-flavor, the panel was asked to name off-flavor and indicate intensity as slight, moderate, or pronounced.

RESULTS AND DISCUSSION

Weight of muscles. The weights of dissected muscles from raw and cooked cuts are an indication of their size. Although some variation in the weight of the individual muscles was noted, the relative size of the muscles within a carcass was about the same for all carcasses. From the largest to the smallest, the muscles were: *Longissimus dorsi, biceps femoris, semimembranosus, semitendinosus, rectus femoris,* and *adductor*. As might be expected, all muscles decreased in weight after the cuts were cooked. The largest decrease in weight, 20%, occurred in the *longissimus dorsi* muscle; the smallest, 10%, in the *adductor*.

Tenderness. Wide variations were noted in the shear values for the muscles from the different carcasses, particularly in the cooked muscles, as shown by the large standard deviations (Table 2). In the raw pork cuts, the *adductor* muscle was generally the most

TABLE 2

Weight, shear force, color, fat and moisture content of selected muscles from eight pork carcasses varying in fatness

Cut and muscle	Weight		Kramer shear force[1]		Color (Hunter "L" values)[2]		Intramuscular fat content[3]		Intramuscular moisture content[3]	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Raw	*g*	*g*	*lb*	*lb*			%	%	%	%
Rib: *Longissimus dorsi*	370	67	152	30	43.5	4.4	5.7	2.3	68.3	2.5
Loin: *Longissimus dorsi*	866	206	214	27	45.9	5.2	6.4	3.7	69.5	2.0
Ham, butt half:										
Biceps femoris	216	41	333	52	33.9	1.8	3.6	1.2	72.1	0.9
Rectus femoris	268	28	209	43	29.2	4.1	2.5	1.0	74.1	1.4
Ham, shank half:										
Semitendinosus	279	34	204	23	40.1	5.3	3.8	1.6	74.2	1.1
Semimembranosus	480	100	210	44	39.8	6.2	2.6	0.7	73.6	0.9
Adductor	108	9	139	30	29.7	3.3	....	....	....	....
Biceps femoris	404	75	383	50	34.6	4.6	....	....	....	....
Test difference[4]			24		2.6		1.4		1.1	
Cooked										
Rib: *Longissimus dorsi*	314	36	212	81	61.2	2.2	7.1	2.6	60.8	1.3
Loin: *Longissimus dorsi*	671	94	222	81	60.5	2.5	6.2	2.4	58.8	2.6
Ham, butt half:										
Biceps femoris	177	28	237	99	50.9	2.6	7.0	1.1	56.9	2.6
Rectus femoris	182	17	224	86	50.4	3.5	4.1	1.1	64.4	1.7
Ham, shank half:										
Semitendinosus	200	25	180	61	52.3	4.5	7.6	1.4	60.8	2.5
Semimembranosus	408	83	332	116	56.0	3.3	4.8	1.9	61.2	3.1
Adductor	97	12	259	97	50.9	4.0	....	....	....	....
Biceps femoris	286	41	241	90	49.7	3.0	....	....	....	....
Test difference[4]			63		1.9		1.3		1.6	

[1] Mean of 16 to 32 determinations.
[2] Mean of 32 readings.
[3] Mean of 24 determinations.
[4] The difference between means from any two muscles is significant at the 5% level when it equals or exceeds the test difference *(5)*.

tender as determined by Kramer shear; the *biceps femoris*, the least tender. In the cooked cuts, the *semitendinosus* was the most tender on the average and the *semimembranosus*, the least tender.

It has been reported that the *longissimus dorsi* muscle is not uniform in tenderness *(10, 14)*. Generally in this investigation, the anterior parts of the raw *longissimus dorsi* and *biceps femoris* muscles were more tender (lower shear values) than the posterior of the muscles. However, in the cooked cuts neither the posterior nor the anterior part was predominately more tender.

Beef muscles have been reported to be more tender in the raw state than when cooked. In this study on the quality of pork, the degree of marbling appeared to influence comparisons between raw and cooked pork from left and right sides of the same carcass. The cooked muscles from the carcass with a high marbling score were more tender than the comparable raw muscles. However, the raw muscles from the carcass with a low marbling score and the least amount of the intramuscular fat were more tender than muscles from the paired cooked cuts. For the other carcasses with moderate amounts of marbling the raw *longissimus dorsi*, *semimembranosus*, and *adductor* muscles and the cooked *semitendinosus* and *biceps femoris* muscles were more tender than corresponding raw and cooked muscles.

The *semitendinosus* muscle was considered to be the most tender by the panel; the *semimembranosus* the least tender (Table 3). The panel found no significant difference in tenderness between the anterior and the posterior of the *longissimus dorsi* muscle in the cooked cuts. These agree with the Kramer shear values on the same muscles. Correlations between Kramer shear and tenderness scores were significant for most muscles (Table 5). The correlation coefficients are negative because low shear values and high panel scores indicate tender meat. The regression of panel scores for tenderness on Kramer shear values is illustrated in Figure 2.

Color—Hunter "L" values. In both raw and cooked rib and loin cuts (Table 2), the *longissimus dorsi* muscle was lighter in color than the muscles in the fresh ham cut. The *adductor* and *rectus femoris* muscles of the raw ham tended to be the darkest in color.

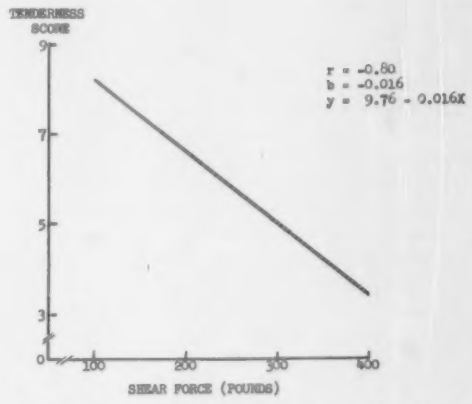

Figure 2. Regression of tenderness scores on shear force values for cooked pork.

Differences in color were small among most of the muscles in cooked ham cuts.

In the raw cuts, differences were observed between the anterior and posterior parts of the *biceps femoris* muscles in five of the carcasses, although neither part was predominately lighter in color. In the cooked cuts, the posterior of the *biceps femoris* was lighter in color than the anterior in half of the muscles, the reverse was noted for one muscle, and no difference in color was observed in the remaining three.

Intramuscular fat content. The intramuscular fat content (ether extract) varied among the different muscles (Table 2). Wider variations in intramuscular fat content among carcasses were noted in *longissimus dorsi* muscles than in the ham muscles. The fat content of one muscle was not always indicative of the fat content of the other muscles in the same carcass. No one muscle in the ham seemed to be a dependable guide to the quality of the whole fresh ham. In the raw cuts, the *longissimus dorsi* muscle tended to have more fat than the ham muscles. The fat content was higher in the cooked muscles than in the comparable raw muscles. Wider variations in the intramuscular fat content among carcasses were noted in *longissimus dorsi* muscles than in the ham muscles. For all muscles the intramuscular fat content was higher in the cooked cuts than in the raw cuts.

TABLE 3

Panel scores for selected muscles from eight pork carcasses varying in fatness

Cut and muscle	Panel scores[1] for—							
	Tenderness		Juiciness		Flavor		General acceptability	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Rib: *Longissimus dorsi*	5.9	1.8	6.1	0.8	5.8	0.8	5.8	1.1
Loin: *Longissimus dorsi*	6.2	1.9	4.5	1.5	5.2	1.2	5.0	1.6
Ham, butt half:								
Biceps femoris	5.3	2.4	4.6	1.7	5.8	1.0	4.8	1.7
Rectus femoris	6.3	2.1	4.0	1.3	5.0	0.9	4.7	1.4
Ham, shank half:								
Semitendinosus	7.0	1.4	5.5	1.0	5.6	0.6	5.6	0.7
Semimembranosus	5.2	2.2	5.4	1.2	5.6	1.3	5.0	1.6
Test difference[2]	1.2		0.8		0.6		0.9	

[1] Mean of 32 scores.
[2] The difference between means from any two muscles is significant at the 5% level when it equals or exceeds the test difference *(5)*.

Moisture content. As would be expected, the moisture content of a muscle (Table 2) varied inversely with the fat content. A wider range in the moisture content of the cooked muscles was observed than for the raw muscles. The muscles in the ham cut, which generally had a low fat content, had a higher moisture content than the *longissimus dorsi* muscle. In the raw cuts, the average moisture content of the muscles from carcasses with high and low backfat thickness was very similar; in the cooked cuts the moisture content was slightly lower in muscles from carcasses with low backfat thickness.

Juiciness, flavor, and general acceptability. Greater variations among muscles were noted in the panel scores for juiciness than in flavor and general acceptability scores (Table 3). Of all the muscles, the anterior (rib end) of the *longissimus dorsi* muscle had the highest mean score for juiciness as judged by the panel; the *rectus femoris* had the lowest. Mean scores for flavor were similar for the different muscles in the loin and ham cuts.

Apparently, all palatability characteristics were interrelated; in some muscles, acceptability was influenced more by juiciness, and in other muscles by tenderness. Upon examination of panel scores, the relation between flavor and acceptability seemed to be close.

Correlation coefficients. The relations between various measures of fatness of raw pork, such as backfat thickness, marbling score, and intramuscular fat content, were usually not significant at the 5% level, although in some cases the correlations were of considerable magnitude (Table 4). Other correlations may be found when the fat content of all the lean of a raw pork cut instead of a muscle is used. Correlations of backfat thickness, marbling score, or intramuscular fat with tenderness of raw pork muscles as measured by Kramer shear were not significant.

The relation between backfat thickness and the intramuscular fat content of cooked pork was significant at the 5% level for the anterior of the *longissimus dorsi* muscle but not for any of the other muscles (Table 5). Correlations of backfat thickness with tenderness scores for cooked pork were not significant; those with juiciness scores for the anterior of the *longissimus dorsi* muscle and the *semitendinosus* muscle of ham were significantly greater than zero at the 5% level.

The degree of marbling in the raw *longissimus dorsi* muscle between the 10th and 11th rib shows promise

TABLE 4

Correlation coefficients between various quality measurements on raw pork

Cut and muscle[1]	Backfat thickness and—			Marbling score[2] and—		Intramuscular fat and Kramer shear
	Marbling score[2]	Intramuscular fat	Kramer shear	Intramuscular fat	Kramer shear	
	r	r	r	r	r	r
Rib: *Longissimus dorsi*	0.52	0.68	0.41	0.74*	0.29	0.45
Loin: *Longissimus dorsi*	.....	.51	.47	.67	.37	.28
Ham, butt half:						
Biceps femoris	.....	.43	.03	.66	.59	.25
Rectus femoris	.....	−.02	.01	.51	.23	.18
Ham, shank half:						
Semitendinosus	.....	.60	−.29	.38	.04	−.40
Semimembranosus	.....	.56	.46	.67	.63	.13

[1] Cuts from 8 carcasses.
[2] Marbling score for the raw *longissimus dorsi*.
* Significant at 5% level.

TABLE 5

Relationships between marbling score and fat content, tenderness, and juiciness of cooked pork

Cut and muscle[1]	Fat content (Y) and—		Tenderness score (Y) and—				Juiciness score (Y) and—		
	Backfat	Marbling score[2]	Marbling score[2]	Fat content	Kramer shear	Backfat	Marbling score[2]	Fat content	Backfat
Correlation coefficients (r)									
Rib: *Longissimus dorsi*	0.78*	0.79*	0.73*	0.80*	−0.74*	0.51	0.85**	0.64	0.77*
Loin: *Longissimus dorsi*	.51	.80*	.84**	.86**	−.91**	.48	.86**	.91**	.40
Ham, butt half:									
Biceps femoris	−.41	−.34	.71*	−.32	−.82*	.48	.77*	−.23	.46
Rectus femoris	.59	.49	.75*	.08	−.94**	.53	.87**	.41	.61
Ham, shank half:									
Semitendinosus	−.10	.14	.32	−.27	−.56	.51	.34	−.42	.74*
Semimembranosus	−.22	.13	.23	−.71*	−.85**	.32	.21	−.82*	.59
Regression coefficients (b)[3]									
Rib: *Longissimus dorsi*	8.2*	1.8*	1.1*	0.54*	-0.016*	....	0.30**	....	2.5*
Loin: *Longissimus dorsi*	....	1.7*	1.4**	.67**	−.021**	....	1.11**	.56**	....
Ham, butt half:									
Biceps femoris	....	....	1.5*	....	−.020*	....	1.10*	....	....
Rectus femoris	....	....	1.4*	....	−.023**	....	.96**	....	....
Ham, shank half:									
Semitendinosus	....	....	....	....	−.012	....	....	....	3.0*
Semimembranosus	....	....	....	−.84*	−.016**	....	....	−.53*	....

[1] Cuts from 8 carcasses.
[2] The marbling score for the raw *longissimus dorsi* was used.
[3] b estimates average change in Y with a unit change in X.
* Significant at 5% level.
** Significant at 1% level.

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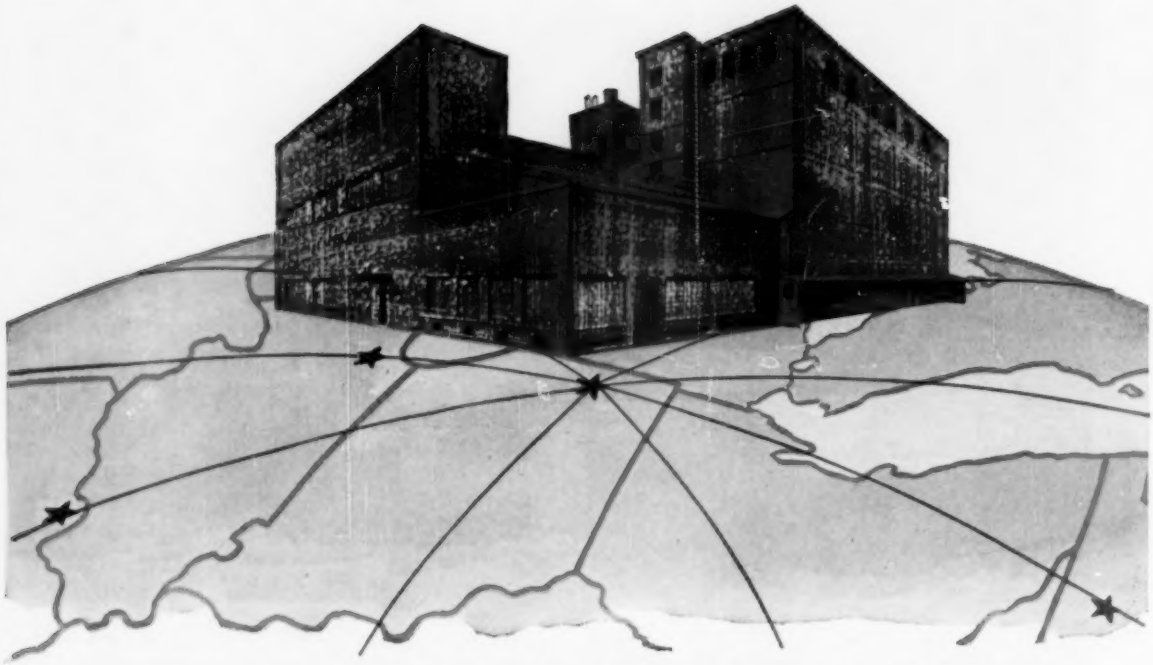

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as an indicator of the juiciness and tenderness of the cooked meat. The regression coefficients showed that there was a significant improvement of 2 to 3 points in the tenderness score of these muscles with an increment of 2 points on the marbling rating scale. Juiciness score increased 1 to 2 points with an increment of 2 points on the marbling rating scale. The correlation coefficients between marbling score and juiciness and between marbling score and tenderness of the cooked *longissimus dorsi, biceps femoris,* and *rectus femoris* muscles were significantly greater than zero at the 5% or 1% level.

Marbling score was highly correlated with intramuscular fat content of the *longissimus dorsi* muscle. Likewise, there was a positive relationship between the fat content of the muscle and tenderness and juiciness of the cooked meat. The regression coefficients indicate that with 3% more fat in the *longissimus dorsi* muscle, there was a tendency for the muscle to be more juicy and more tender by about 2 points. The regression of panel scores for tenderness for pork varying in degree of marbling is illustrated in Figure 3.

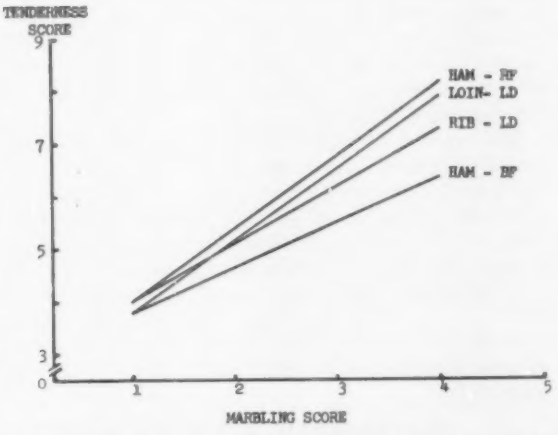

Figure 3. Regression of tenderness scores for pork varying in degree of marbling.

Fat content of the ham muscles, on the other hand, did not appear to be related to the marbling score of the *longissimus dorsi* muscle. Furthermore, fat content of the ham muscles was not related to the tenderness or juiciness of the cooked muscles in 3 out of 4 cases. In one muscle, *semimembranosus,* there was an increase of 1.5 to 2.5 points in tenderness and juiciness scores with a decrease of 3% in the intramuscular fat. The correlations of juiciness with moisture content were significant for 3 out of 4 of the ham muscles, as follows: *Semitendinosus* 0.92, *semimembranosus* 0.78, and *biceps femoris* 0.78. Thus, factors other than fat appeared to be influencing the tenderness and juiciness of these muscles of cooked ham.

Data are being obtained on more carcasses to obtain a more accurate estimate of the relationships of the various quality factors.

SUMMARY

An investigation of the consumer quality of raw and cooked pork muscles from hogs varying in fatness is reported. The degree of marbling in the raw *longissimus dorsi* muscle between the 10th and 11th ribs shows promise as a means of predicting the tenderness and juiciness of cooked loin and ham cuts of pork. Greater variations in fat content, color, and tenderness were noted among muscles from some carcasses than from others. It would appear that more than one muscle should be used to evaluate the quality of a cut because muscles vary so greatly.

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Factors Affecting the Water Retention of Beef. II.

Variation in Some pH Determinants Among Eight Muscles[a]

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ONE OF THE MOST IMPORTANT properties of meat is its capacity to retain water or juice, since this ability directly affects results in meat cookery, meat storage, and the manufacture of meat products. The ultimate object of the present and other researches concerned with the factors affecting water retention is to develop a basis for controlling or, when desired, enhancing the capacity. In attaining this goal, a broad basic knowledge of factors influencing water retention is required.

In a previous report involving a comparative study of the properties of muscles, it was shown that the water retention, ultimate pH, and other properties of a series of eight muscles from each of a small group of bovine animals followed definite patterns *(16)*.[b] The finding that variation of the properties of the eight muscles occurred and that variations followed a pattern was in itself important. For the statistical analyses, data were grouped according to the identity of the muscles. Significant correlations were obtained between water retention and positively related components, including pH values, zinc and fat content, and ratios of moisture to protein content, and negatively related components, including protein content and calcium, magnesium, and potassium content. Because of the close relation observed between the pH and water retention of the muscles in the series, emphasis was subsequently given to a study of factors influencing the ultimate pH of the same eight muscles.

Some knowledge of factors which contribute to variation of the ultimate pH of muscles or meat has previously been obtained. As pointed out by Bate-Smith *(1)*, the differences in the ultimate pH of muscles and meat would appear to be attributable to variations in the pH of muscles *in vivo*, in the amount of glycolytic activity occurring after slaughter, and in the amount of buffering encountered. Bate-Smith and Bendall *(3)* reported that the ultimate pH and the original or initial glycogen content of muscles were related and that content of lactic acid correlated with, if it was not responsible for, variations in pH.

According to reports by Callow *(4)* and Lawrie *(11)*, sizable residues of glycogen may be present in muscles after the ultimate pH has been attained. Howard and Lawrie *(9)* showed that the ultimate pH of a series of four steer muscles varied with glycogen content, except that other factors determined the extent of glycolysis and, hence, ultimate pH, if the muscles contained an excess of glycogen. The data given indicated that the latter situation occurred more frequently. The four muscles whose properties were investigated had relatively similar properties. Hall *et al. (7)*, in work also dealing with muscle pH, explained the difference between dark and bright muscles, which characteristically had high and low pH values, respectively, on the basis of the low glycogen content of the former at the time of slaughter. An association between high pH and low content of water soluble protein and aldolase has been reported by Kronman and Winterbottom *(10)*.

The present investigation of pH determinants followed the general procedure of the first paper of the series and was a comparative study of the properties of eight muscles from several animals. Determinations of pH values, glycogen content, buffering capacity, and total and water-soluble nitrogen content were involved. Experiments were also conducted to determine the effects of adding alkali and ATP (adenosine triphosphate) on the residual glycogen content of some ground muscles which had attained their ultimate pH.

EXPERIMENTAL AND RESULTS

Animals and muscles used. Carcasses of 7 animals were obtained immediately after slaughter. The 6 animals whose carcasses were used to provide samples for the principal series of analyses were 3 steers (A, B, and C, Table 1), 2 bulls (D and E), and a cow (F). The remaining animal, a heifer, was used to obtain samples for an investigation of the solubility of the nitrogen components of the muscles. One side was stored at 3° C, while, from the other side, the 8 muscles used in the experiments were removed as quickly as possible. The names of the muscles and the numbers with which they are coded in the present report are as follows: 1) *Longissimus dorsi*, 2) *Psoas major*, 3) *Semimembranosus*, 4) *Serratus ventralis* (thoracic), 5) *Rectus abdominus*, 6) *Semitendinosus*, 7) *Latissimus dorsi*, and 8) *Trapezius*. Physically separable fat and connective tissue were removed. Each muscle was cut into cubes and about 16 cc in size and the cubes were thoroughly mixed. These operations were completed approximately 2 hours after the death of the animals.

Analytical methods. Glycogen was determined by the method of Good, Kramer, and Somogyi *(6)*. Determinations on fresh tissue from 8 muscles of each of 6 animals (A to F, Table 1) were begun immediately after the muscles were cubed or, otherwise, cubes were frozen by immersion in liquid nitrogen and held at −18° C until analyzed 2 days later. Other glycogen determinations were made on samples of muscles from four of

[a] Presented in part at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 19, 1959.

[b] It is especially important to note that the method followed in selecting muscles and in analyzing results in both the present and previous *(16)* reports emphasizes variations between the properties of muscles and excludes between-animal effects.

TABLE 1

Glycogen and protein contents, ultimate pH values, and buffering capacity of eight beef muscles from six different animals and their interrelation

Animal	Muscle number	Glycogen[1] mg/100 g	Protein (N x 6.25) %	pH (ultimate)	Buffering capacity equiv/pH/g	Statistical correlations[2]			
						Glycogen with protein	pH with protein	Buffering with pH	pH with glycogen[3]
A (steer)	1	560	21.4	5.61					
	2	580	21.7	5.35					
	3	540	22.1	5.52					
	4	325	18.3	5.77					
	5	515	20.0	5.85					
	6	545	22.0	5.60					
	7	590	21.2	5.61					
	8	430	19.6	5.78					
						0.890±0.057***	−0.754±0.111**		−0.604±0.190
B (steer)	1	783	22.7	5.61					
	2	217	20.6	5.61					
	3	1013	22.5	5.54					
	4	196	18.8	6.01					
	5	244	20.8	6.18					
	6	1014	22.1	5.60					
	7	488	22.1	5.59					
	8	233	20.2	5.83					
						0.825±0.088***	−0.701±0.139**		−0.805±0.105**
C (steer)	1	964	20.5	5.49	5.83				
	2	165	19.3	5.52	5.15				
	3	1106	20.9	5.44	7.17				
	4	449	17.1	5.82	3.40				
	5	485	20.2	5.82	4.81				
	6	719	20.1	5.59	5.20				
	7	880	19.8	5.61	5.29				
	8	734	18.3	5.63	4.47				
						0.518±0.203	−0.588±0.180	−0.822±0.089**	−0.967±0.019***
D (bull)	1	809	20.9	5.45	7.89				
	2	128	20.0	5.51	5.47				
	3	807	22.2	5.43	8.50				
	4	542	20.6	5.72	3.33				
	5	145	20.8	5.70	3.89				
	6	457	21.3	5.46	6.73				
	7	842	22.0	5.52	6.37				
	8	489	21.0	5.62	4.30				
						0.736±0.126**	−0.426±0.219	−0.948±0.027***	−0.675±0.163*
E (bull)	1	779	22.3	5.49	6.97				
	2	640	21.0	5.49	6.97				
	3	796	22.0	5.50	7.65				
	4	440	19.5	5.73	3.72				
	5	600	21.7	5.62	5.58				
	6	657	21.4	5.50	7.77				
	7	954	21.0	5.50	7.05				
	8	540	21.1	5.70	4.86				
						0.569±0.186*	−0.654±0.158*	−0.962±0.020***	−0.859±0.078**
F (cow)	1	460	24.1	5.58	7.29				
	2	106	22.7	5.62	6.49				
	3	430	24.0	5.53	6.80				
	4	215	21.0	6.09	3.76				
	5	130	22.3	5.80	3.96				
	6	147	22.5	5.58	7.09				
	7	253	23.5	5.55	7.29				
	8	170	22.6	5.88	4.50				
						0.702±0.139**	−0.854±0.072***	−0.920±0.042***	−0.491±0.227

[1] Determined 2–3 hr after slaughter.

[2] Statistical significance at 10, 5, and 1% levels indicated by 1, 2, and 3 asterisks, respectively: Correlations, coefficients, ± probable error are shown.

[3] Data on *psoas* muscle omitted in calculations.

the animals (C, D, E, and F, Table 1); determinations were made on tissue ground 9–10 hr after slaughter, and on this ground tissue 18 hr later. The tissue was exposed to ambient temperatures for approximately 2 hr after slaughter and stored at 3° C thereafter. The calculations of the average initial content of glycogen of the muscles (Figure 1) were based on the method used by Howard and Lawrie *(9)* and Bate-Smith *(1)* who calculated the minimum quantity of glycogen needed to attain the fixed (ultimate) pH, assuming an initial pH of 7.2 and taking the buffering capacity of the muscles into account. However, in the calculation of the estimated original glycogen content presently reported, the quantity of residual glycogen determined to be present in the muscles, when the ultimate pH was attained, was added to the glycogen calculated to have been utilized in glycolysis after slaughter.

Buffering capacity was determined on muscles from animals C, D, E, and F by the method described by Bate-Smith *(1)*, except that 10-g samples were employed. Additions of alkali were made at 15-min intervals during the titration. The determinations were made at 3–4 and approximately 28 hr after slaughter on ground samples prepared from cubed muscles. Samples of muscles aged 2 weeks were prepared by grinding portions of the muscles removed from the other sides of the carcasses of animals E and F, which had been refrigerated at 3° C, dating from the day of slaughter. Buffering capacity was calculated as the equivalents of alkali required to change 1 g tissue (in a 1:1 slurry with water) from pH 6 to 7 and is reported as equiv/pH/g x 10^{-3}.

Protein was determined as described by the *Official Methods of Analysis*, AOAC *(15)*. Water-soluble nitrogen was determined on water extracts of ground muscle tissue. Mixtures of water-tissue (1.66:1) were prepared one day after slaughter and allowed to stand overnight. Nitrogen was then determined in aliquots of centrifugally clarified supernatant fluid. Differences in the water retention of the different samples of tissue were taken into account in calculating the quantities extracted. The ultimate pH values reported were obtained with a Beckman Model G pH meter[c] on 1:1 mixtures of distilled water and ground tissue approximately 28 hr after slaughter.

Five experiments were conducted with ground diaphragm muscles from different animals 24, 7, and 48 hours after slaughter as follows: To 5 g tissue (a) 5 ml water, (b) 5 ml water

[c] The mention of specific trade names throughout this paper does not constitute endorsement of the product used over comparable ones.

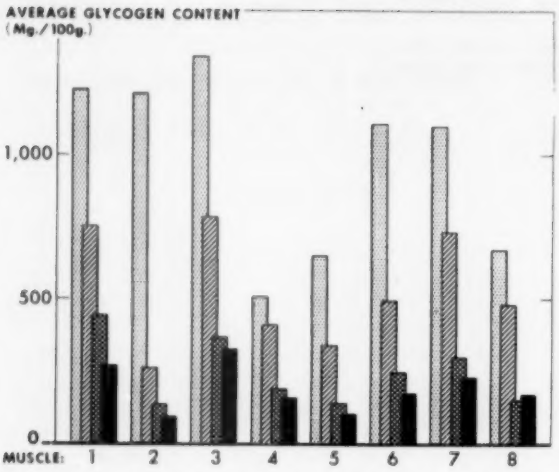

Figure 1. Average glycogen content of eight muscles at slaughter (calculated), after 3 hours at ambient temperatures, and after 7 and 25 subsequent hours of storage at 3° C.

Content at slaughter (calculated).

Content approximately 3 hours after slaughter.

Content 10 hours after slaughter.

Content 28 hours after slaughter.

and 10 mg ATP (treatment omitted in one experiment), (c) 4 ml water and 1 ml .25N NaOH, and (d) 4 ml water, 1 ml .25N NaOH, and 10 mg ATP, were added. The mixtures were allowed to stand overnight, and the glycogen content of the samples was determined. In the fourth and fifth experiment, the lactic acid content of the samples was also determined. All determinations were done in duplicate.

RESULTS AND DISCUSSION

As indicated in the first report of the series *(16)*, variation of pH over a relatively narrow range was correlated directly and closely with capacity for water retention (r = .95). As shown by the data in Table 2,

TABLE 2

Average glycogen and protein content, ultimate pH values, and buffering capacity of eight beef muscles from six different animals and their relations[1]

Muscle	Glycogen mg/100 g[2]	Protein (N x 6.25) %	pH (ultimate)	Buffering capacity equiv/ pH/g x 10^{-5}
1	725	22.0	5.54	7.00
2	306	20.9	5.52	6.02
3	782	22.3	5.49	7.53
4	361	19.2	5.86	3.43
5	353	21.0	5.83	4.56
6	590	21.6	5.56	6.70
7	668	21.6	5.56	6.60
8	433	20.5	5.73	4.54

Correlations (correlation coefficients ± probable error):
Glycogen and protein (N x 6.25) 0.856 ± 0.074***[3] (0.794 ± 0.102**)[4]
pH and protein (N x 6.25) −0.804 ± 0.097**
Buffering capacity and pH (based on data on 4 animals) −0.982 ± 0.010***
pH and glycogen −0.969 ± 0.017***[3] (−0.652 ± 0.159*)[3]
Statistical significance at 10, 5, and 1% levels indicated by 1, 2, and 3 asterisks, respectively.

[1] Averages of 8 muscles from 6 animals, except that data on buffering capacity was obtained on only 4 animals.
[2] Determined 2–3 hr after slaughter.
[3] Based on averages, omitting muscle No. 2 *(psoas)*.
[4] Based on averages, including muscle No. 2 *(psoas)*.

the range of the average pH of the 8 muscles was 5.49 to 5.86 (6 animals), which compares with the range 5.50 to 5.79, previously reported by the authors for the series of muscles of another group of animals *(16)*.

Also in the earlier work, variation of pH was shown to be closely, but negatively, related to protein content (r = −0.89). As shown in Table 2, the relation between pH values and the protein content of the muscles of the 6 additional animals, which have been more recently studied, was similarly inverse (r = −0.804). This seemingly paradoxical relationship, wherein pH values and water retention vary negatively with protein, although protein is the component assumed to be principally responsible for the water retention by muscle, appears to be explained by the relation of glycogen content to protein content of the muscles as noted below.

The data in Table 2 show that the glycogen content of the muscles, determined immediately after slaughter, was directly related to protein content. In view of this glycogen-protein relationship, the premise appears acceptable that protein content *per se* has been found to be negatively related to pH only because of the close association of protein content with glycogen content, and that glycogen content alone has a cause and effect relationship with ultimate pH. The correlation of average glycogen content to average protein content was r = 0.794 ± 0.102 when the *psoas* muscle was included, but increased to r = 0.856 ± 0.074 when data on the *psoas* muscle was omitted. The relation of average ultimate pH values to average glycogen content was r = −0.652 ± 0.159 when the data on the *psoas* muscle were included, but changed to r = −.0.969 ± 0.017 if the data on the *psoas* muscle were excluded. In calculating the results shown in Table 1, excluding data on the *psoas* muscle also improved the correlation between the ultimate pH and glycogen content of muscles of individual animals, but not that between glycogen and protein content. The *psoas* muscle apparently differed owing to its participation in the death struggle. As Bate-Smith *(2)* has previously pointed out, this tends to markedly deplete the muscle's store of glycogen. The above close relation of glycogen to protein content would probably not be valid under circumstances such as explored by Howard and Lawrie *(9)* in which abnormal preslaughter treatments resulted in high ultimate pH values.

The average glycogen content of the 8 muscles from 4 animals at periods corresponding to slaughter time, 3 hr at ambient temperature, and after seven and 21 hr of subsequent storage at 3° C is shown in Figure 1. The marked decrease in the glycogen content of muscles attaining low ultimate pH values (Nos. 1, 3, and 6) contrasts with the lesser decrease in those attaining higher ultimate pH values (Nos. 4, 5, and 8) at all three designated time periods. Calculations were made of the average rate of glycolysis of 7 muscles (*psoas* omitted) during the first 3 hours, during the following 7 hr, and during the subsequent 18 hr. The range of the rates of glycolysis during the first 3 hr varied from 31 to 250 mg glycogen per hr,

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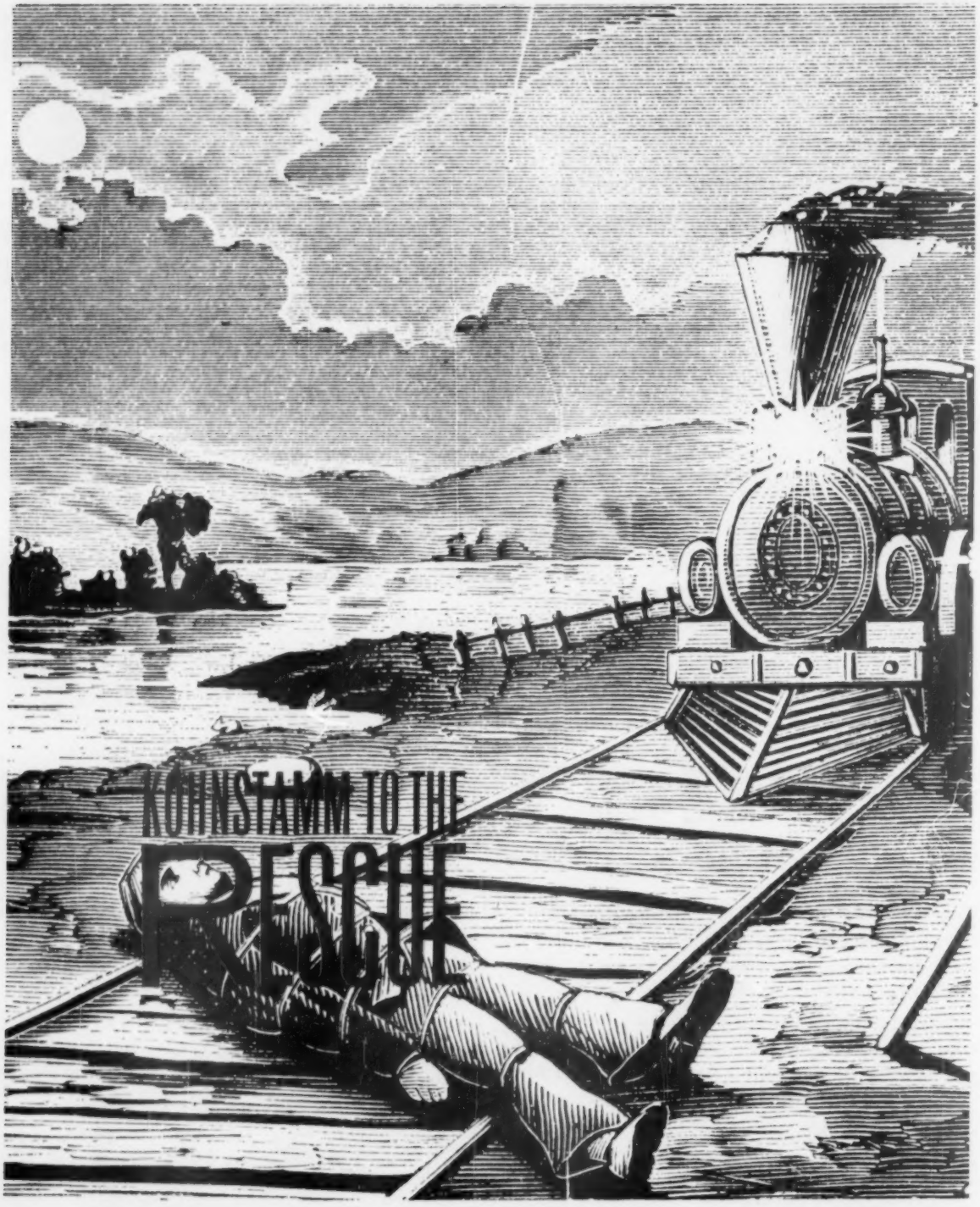

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the rate varying linearly with the initial (calculated) glycogen content ($r = 0.880 \pm 0.064$, $P<.01$). During the following 7 hr the rates of glycolysis ranged from 29 to 59 mg glycogen per hr and were linearly related to the glycogen levels determined 3 hr post mortem ($r = 0.846 \pm 0.085$, $P<.02$). The rates during the last 18 hr were low and differences were not significant. These data show a direct relation between glycogen content and glycolytic rates. The possible variation in capacity of the glycolytic enzyme systems in the muscles is not precluded by the present results. As previously mentioned, variation in the aldolase content of different muscles has been reported in earlier work *(10)*.

Calculations based on the estimated original glycogen content and the buffering capacity of the muscles indicate that muscles Nos. 4, 5, and 8 would have attained ultimate pH values in the region of pH 5.49, the average ultimate pH of muscle No. 3, if glycolysis had reached completion.

The curve in Figure 2 shows post slaughter disappearance of glycogen, based on averages of data on all muscles of 4 animals. Glycolysis occurred rapidly at first, and then at a relatively slower rate. After storage for 28 hr, substantial residues remained which were equal to approximately 20% of the estimated glycogen content of the muscles at zero time.

A curve is shown in Figure 3 expressing the relation between average residue of glycogen (after 28 hr post slaughter storage) and the average pH of the 8 muscles from four animals. The point plotted at pH 5.52 represents the *psoas* muscle and, as has been previously indicated, glycolysis in this muscle did not conform to the pattern fixed by the other muscles. Although, for this reason, the point at pH 5.52 was disregarded in constructing the curve, it is shown for the sake of completeness. All 8 muscles contained residual glycogen, consequently, lack of glycogen would not appear to have caused cessation of glycolysis. Variation of the original content of glycogen has been found to be related to varying glycolytic rates. The content of glycogen originally present in muscles attaining low pH values, as well as that residual in such muscles (Figure 3) was larger (with the exception of the *psoas*, which has been shown to be subject to depletion) than in those attaining high pH values. The added availability of substrate in muscles attaining the lowest ultimate pH values appears to be associated with an increased rate of glycolysis in these muscles, causing the rates of glycolysis to vary positively with glycogen content (and negatively with ultimate pH). If one or more participants in glycolysis is subject to inactivation or decomposition, the relative rates of glycolysis and of this inactivation or decomposition would determine the extent of glycolysis to be expected.

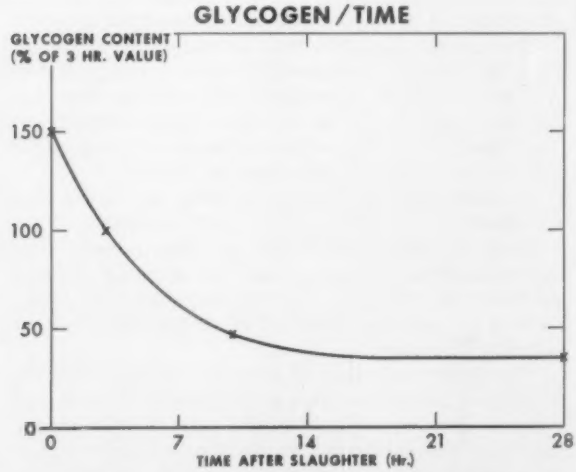

Figure 2. Average content of glycogen of 32 muscles at slaughter (calculated), after 3 hours at ambient temperatures, and after 7 and 25 subsequent hours of storage at 3° C.

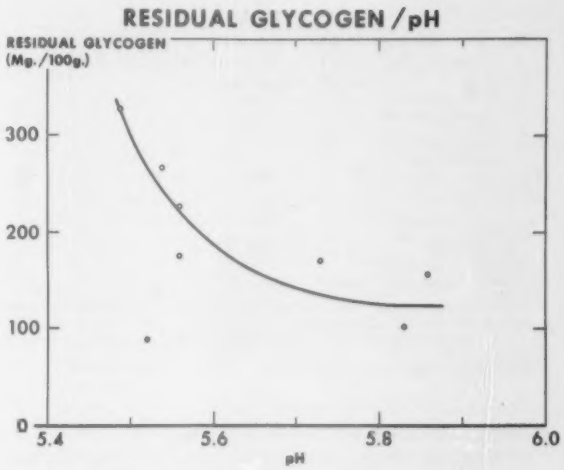

Figure 3. The relation of average residual glycogen content to the average ultimate pH of eight muscles.

The need for ATP in glycolysis has been recognized, dating from the work of Lohman *(12)*. The rate of disappearance of ATP would appear to affect the extent of glycolysis inasmuch as ATP is a participant. The rate of pH decrease and of ATP disappearance has previously been shown to be closely linked in studies of rigor *(13)*. As shown by the data in Table 3, the addition of both alkali and ATP stimulated glycolysis, as indicated by the added disappearance of glycogen in samples to which these substances were added. The addition of ATP was necessary for production of lactic acid. Evidence has previously been presented relative to this effect of alkali addition *(7)*. The evidence thus suggests that the decrease in pH produced during glycolysis tends to inhibit the overall reaction. The marked response to the addition of ATP in all cases, but particularly when ATP was added with alkali, supports the assumption that lack of ATP is responsible for, or at least contributes to, the cessation of glycolysis in the muscles.

The foregoing results indicate that glycolysis occurred at different rates in the muscles which were closely associated with differences in original glycogen

TABLE 3

Effects of addition of alkali and ATP on residual glycogen content (mg/100 g) in one rectus abdominus and four diaphragm muscles

Experiment[1]	1	2	3	4	5
Post slaughter age of tissue, hrs	24	7	48	24	24
Treatment[2]					
5 ml H_2O	492	834	96	160 (rect)[3]	397 (rect)[3]
5 ml H_2O, 10 mg ATP	449	832	....	136 (rect)	371 (rect)
4 ml H_2O, 1 ml .25N NaOH	423	717	56	93 (diaph)	318 (diaph)
4 ml H_2O, 1 ml .25N NaOH, 10 mg ATP	287	608	8	64 (diaph)	201 (diaph)

[1] Diaphragm muscle was used in Experiments 1, 2, 3, and 5, and *rectus abdominus* in Experiment 4.

[2] Five grams ground tissue treated and allowed to stand overnight at 3° C.

[3] Lactic acid content, mg/100 g.

TABLE 4

Buffering capacity of fresh muscles and muscles stored at 3° C

Muscle No.	Buffering capacity, equiv/pH/g x 10^{-6}					
	Animal D			Animal E		
	Fresh	28 hours	2 weeks	Fresh	28 hours	2 weeks
1	9.43	7.89	6.15	7.77	6.97	6.64
2	5.71	5.47	5.37	7.41	6.97	5.29
3	8.16	8.50	7.41	8.09	7.65	5.71
4	4.86	3.33	3.47	4.25	3.72	3.40
5	4.57	3.89	4.69	5.42	5.58	5.47
6	8.26	6.73	6.10	8.70	7.77	5.71
7	7.92	6.37	7.53	6.97	7.05	5.71
8	4.84	4.30	4.06	6.38	4.86	4.98
Mean[1]	6.719>*	5.850	5.598	6.874>*	6.321>*	5.364

* Significant at 5% level.

[1] Means of fresh, 28-hr, and 2-week old samples of both animals were 6.796, 6.086, and 5.481, respectively, the difference between the first two being significant at the 5% level and the latter two at the 10% level.

TABLE 5

Total and water-soluble fraction of nitrogenous components of eight muscles from a heifer

Muscle No.	pH	Nitrogenous components	
		Total as protein, N x 6.25 %	Fraction soluble in water %
1	5.60	22.8	22.0
2	5.52	21.5	20.1
3	5.50	22.6	23.6
4	5.85	16.1	16.3
5	5.63	21.5	18.6
6	5.58	23.0	21.3
7	5.61	21.6	20.9
8	5.73	20.6	18.3

Correlations: Total and percentage soluble in water, $r = 0.883 \pm 0.067$, $P<.01$

pH and percentage soluble in water, $r = -0.866 \pm 0.069$, $P<.01$

content, and that glycolysis had proceeded to a different extent among the muscles when the process was terminated. An assumption that termination was caused by disappearance of ATP and the inactivity of the ATP-dependent steps of glycolysis is consistent with both the present results and accepted concepts of glycolysis *(14)*.

Variations in buffering capacity would be expected to modify the effects of glycolysis in determining ultimate pH. As indicated by the results of measurements of buffering shown in Table 1, the buffering capacity of the muscles varied by the ratio 1 to approximately 2.5. As shown by the statistical data in Table 2, low buffering capacity was associated with high ultimate pH [d] ($r = -0.973 \pm 0.015$). Consequently, buffering varied so as to minimize the pH differences anticipated from the amount of glycolysis occurring in different muscles.

Data presented in Table 4 on the changes in buffering capacity produced by storage indicate that buffering capacity is highest in fresh muscle and declines somewhat during storage. The decreases observed were general; however, the relative buffering capacity of the muscles was not greatly changed. Hamm *(8)* has recently reported that the buffering capacity of fresh muscle is greater than that of one-day old muscle. Since the method used in determining buffering capacity involved titration of water-tissue mixtures, the water solubility of nitrogenous substances would appear to be directly associated with the buffering afforded by the muscles. The data in Table 5 show the relation of the solubility of nitrogenous compounds to total protein content and to ultimate pH values. The percentage of nitrogenous materials soluble in water was found to be directly related to protein content ($r = 0.883 \pm 0.067$). Consistent with the fact that the protein content of the series of muscles has been shown to be inversely related to pH, the percentage of nitrogenous substances soluble in water had a negative relation to pH ($r = -0.866 \pm 0.069$). The tendency of muscles of low protein content to contain the smallest percentage of soluble components should tend to enhance the effect of variation of protein content on buffering.

[d] It has been shown that high ultimate pH is related to a low content of trichloracetic acid soluble nitrogenous substances *(5)*. Since the trichloracetic acid soluble fraction includes the buffers, carnosine and anserine, the low buffering associated with high ultimate pH values appears to be accounted for.

SUMMARY

A comparative study of the glycogen and protein content, pH, and buffering capacity of eight different muscles from each of seven bovine animals was conducted to investigate factors contributing to a pattern of differences in the ultimate pH values of the muscles.

The results show that both glycogen and buffering capacity varied considerably among the muscles. Variation of both glycogen and buffering capacity followed patterns, as has previously been shown to be characteristic of the series of muscles with regard to pH, water retention, and other properties.

A statistically significant positive correlation was obtained between glycogen and protein content.

Since the data showed that all eight muscles contained residual glycogen when the ultimate pH was attained, the relatively high characteristic pH of certain of the muscles could not be simply attributed to a lack of glycogen.

The content of residual glycogen was found to be largest in muscles attaining the lowest ultimate pH values. The same muscles originally contained the largest glycogen stores. It was found that variation of concentrations of glycogen could be closely correlated with rates of glycolysis, which affect the total glycolysis that occurred.

Data were presented indicating that pH decrease and disappearance of ATP contributed to the arrest of glycolysis, as is consistent with accepted concepts of the glycolytic process.

A highly significant negative correlation was found between buffering capacity and pH. Buffering capacity tended to be largest in muscles in which low pH is a characteristic. Consequently, buffering varied so as to minimize the pH differences anticipated from the amount of glycolysis occurring in different muscles.

An explanation of the observed variation in the pH of the series of muscles has been advanced, namely, that ultimate pH varied with the amount of glycolysis occurring prior to ATP disappearance and that the amount of glycolysis occurring during this interval was affected by variations in rates. This variation in rates has been correlated with differences in the amounts of original glycogen stored, but does not preclude variations in the capacity of the glycolytic enzyme systems in the muscles.

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Effect of Temperature on Stability of Frozen Cakes[a]

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(Manuscript received June 12, 1959)

CAKES ARE WELL ADAPTED to preservation by freezing, and the practice is widely used by commercial bakers and homemakers. Several reports *(2, 3, 4, 6, 15)* attest to the relative tolerance that cakes have toward variations in freezing and defrosting practices that are so important with bread and related items *(2, 11)*. A previous report from this laboratory indicated that rate of freezing or defrosting had no significant effect on flavor or texture qualities of cakes, as judged by taste panels *(13)*. Physical measurements on cakes held at refrigerated and frozen temperatures (10° and 0° F), however, indicated that slow changes occur in crumb firmness *(12)*; other reports also indicate that cakes undergo detectable changes in flavor or texture during frozen storage *(7, 8, 9, 14, 16)*, but specific information regarding stability of frozen cakes is scanty. The present paper is concerned with time periods required for detectable organoleptic changes to occur in each of 5 kinds of commercial cakes held at different refrigerated or subfreezing temperatures.

MATERIALS AND METHODS

The cakes used for all but one experiment with yellow layer cakes were produced in the laboratory from commercial formulas selected to represent major types normally encountered. All were relatively high-ratio or otherwise of sufficiently rich formulation that they would be considered as medium to high-quality representatives of their types. Chocolate and yellow layer cakes were scaled at 14 oz of batter and were baked in 9-in commercial layer-cake pans. Angel food, chiffon, and pound cakes were baked in aluminum-foil loaf pans measuring 8 x 4 x 2½ in high. Chiffon and angel food batters were scaled at 8 oz and pound cake batter at 14 oz for these pans.

Layer cakes were wrapped with heat-sealing, moisture-resistant cellophane, 0.0010 in thick, and then enclosed in a polyethylene poultry bag. Cakes baked in foil pans were covered with aluminum-foil paperboard laminated lids crimped to the pans and likewise enclosed in polyethylene to minimize pick-up of foreign flavors and odors. The wrapped cakes were placed in cold rooms maintained automatically at 10°, 0°, −10°, or −30° F within ±2° F. Frozen cakes were allowed to thaw 4 hours at room temperature before being used for taste-panel evaluations.

Taste panel comparisons for the most part were conducted by means of a duo-trio test in which a labeled control sample and an unlabeled control were presented to the judges together with the sample being evaluated. Judges were asked to indicate the sample most like the labeled control and to indicate their preference, if any, between the two coded samples on the basis of softness, freshness, or other criteria.[c] One experiment with yellow layer cake was conducted using a rank method of comparison in which both a hidden and a labeled control sample were used.

Control samples for the various comparisons were fresh unfrozen cake 4 hr after baking, unfrozen cake held 24 hr at room temperature after baking, or frozen cake held at the lower of any 2 temperatures being compared.

Significance of results in the ranking tests was determined by analysis of variance applied separately to each set of comparisons. The Duncan multiple range test *(5)* was used for comparisons of the mean ranks in each set. For the duo-trio method, significance of results was calculated by a chi-square method described by Boggs and Hanson *(1)* and applicable to paired difference tests. Statistically significant differences were not accepted for termination of experiments until the selected probability level (5% point) was exceeded in at least two successive weekly comparisons.

Taste panels were composed of 10 to 15 laboratory and office workers selected for consistency of detection of differences in flavor and texture of the kinds of cake with which they were trained. Two panel sessions were conducted for each time period for each temperature. Judges were given separate sets of samples for flavor and for texture appraisal. Texture differences undoubtedly influenced flavor judgments, but we have not been able to devise a method to avoid this bias.

As difficulty is often encountered in obtaining numbers of cakes of satisfactory uniformity *(10, 12)*, precautions were taken to minimize the influence of this factor. Available laboratory facilities permitted baking of from 12 to 20 cakes or layers from a single batch of batter. Cakes from each batch were therefore coded and placed in designated cold rooms so that later comparisons would be made only between cakes from the same batters but exposed to different temperatures. Selection of cake pairs was otherwise randomized as much as possible. Particular care was taken to avoid use of freshly baked control cakes that differed from the stored cakes in volume or in visible crumb-grain characteristics. Comparisons occasionally were repeated and a few times results were discarded completely when no opportunity existed to repeat a given comparison with acceptable control cakes.

RESULTS AND DISCUSSION

Yellow layer cakes. The initial experiment with yellow layer cakes was conducted with commercially produced cakes. Samples stored at −30° F were used as controls, because facilities were not available at that time to produce freshly baked control cakes when needed. Rank comparisons were made at weekly intervals using separate samples for flavor and texture characteristics. Results obtained for a 14-week experiment are shown in Table 1.

TABLE 1

Time in weeks to first consistent significant difference (5% point) between yellow layer cakes exposed to different temperatures

Comparison	Flavor	Texture
10° vs −30° F	9	10
10° vs −10° F	11	11
10° vs 0° F	13	>14
0° vs −30° F	>14	0
0° vs −10° F	>14	14
−10° vs −30° F	>14	>14

[a] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 20, 1959.

[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

[c] A preference is reported only when there was a significant number of judgments favoring one sample.

In only about half of the comparisons were significant differences evident by the end of the 14-week experimental period. Sensitivity of the panel to differences in texture or in flavor varied in such a way that neither appeared to be the more reliable index of significant change. Samples exposed to 10° F were distinguished from samples held at lower temperatures in an order consistent with the difference in temperature. A similar consistency was found for texture differences. In general, little advantage is gained by holding yellow layer cakes at temperatures below 0° F.

After facilities became available for production of cakes in the laboratory, a second experiment was conducted with yellow layer cakes produced by the commercial formula for the cakes used in the first experiment. The duo-trio test was used in an effort to improve the sensitivity for detection of differences between the frozen cakes and to permit direct comparisons with fresh cakes. In this experiment, only 10° and −30° F temperatures were used. Results are summarized in Table 2.

TABLE 2

Time in weeks to first significant difference (5% point) between yellow layer cakes exposed to different temperatures when compared with each other and with fresh cakes

Comparison	Flavor		Texture	
	Time	Preference	Time	Preference
10° F vs Fresh	8	Fresh	2	Fresh
−30° F vs Fresh	>10	Neither	6	Neither
10° vs −30° F	10	−30° F control	9	−30° F control

Differences significant at the 5% point appeared most quickly with regard to texture when the frozen cakes were compared with fresh cakes. In confirmation of the first experiment, however, neither factor was much more sensitive when the two frozen cakes were compared with each other. The 9 weeks required for reliable differentiation between the frozen cakes (10° versus −30° F) confirms the earlier results. From the second week onward, the panel consistently preferred the cakes held at −30° F.

Cakes stored at 10° F were distinguished from fresh cakes on the basis of texture within two weeks; at −30° F, 6 weeks were required. At the higher temperature, the panel consistently preferred the fresh samples, whereas, at the lower temperature, a clear cut preference did not develop for either the frozen or fresh cakes throughout the 10-week duration of the experiment.

Changes in texture of yellow layer cake included an easily discernible loss of crumb resiliency. For example, as time increased, samples of crumb showed a declining ability to recover their original shape after deformation by finger pressure. At temperatures of 0° F and below, the crumb seemed gradually to become softer. It also showed an increasing degree of gumminess or pastiness when eaten. At 10° F, these changes did not occur. Rather, the crumb became progressively firmer and harsher.

The principal change in flavor and aroma was a gradual decline in intensity of vanilla and other substances contributing to the organoleptic characteristics of fresh cakes. Eventually, the cakes tasted flat and little more than salty-sweet. No characterizable stale or other off-flavors were observed.

Chocolate layer cakes. The experiments with chocolate layer cakes were quite similar to the second series of experiments conducted with yellow layer cake except that temperatures of 10°, 0°, −10°, and −30° F were used. Freshly baked cakes served as controls. In addition, cakes held at 10° F were compared with cakes held at −10° F, as representing the extremes of temperature commonly encountered in retail bakery and home freezing practice. Results are summarized in Table 3.

TABLE 3

Time in weeks required for first significant differences (5% point) between cakes exposed to different temperatures and freshly baked controls or between cakes held at 10° and −10° F

Comparison	Flavor		Texture	
	Time	Preference	Time	Preference
Chocolate layer				
10° F vs Fresh	1	Neither	1	Neither
0° F vs Fresh	3[1]	Neither	3[1]	Neither
−10° F vs Fresh	1	Frozen	1	Frozen
−30° F vs Fresh	2	Frozen	2	Neither
10° F vs −10° F	4	−10° F	4	−10° F
Chiffon				
10° F vs Fresh	1	Fresh	1	Fresh
0° F vs Fresh	1	Fresh	2	Fresh
−10° F vs Fresh	5	Fresh	4	Fresh
−30° F vs Fresh	5	Fresh	5	Fresh
10° F vs −10° F	1	−10° F	1	−10° F
Angel food				
10° F vs Fresh	1	Fresh	1	Fresh
0° F vs Fresh	2	Fresh	2	Fresh
−10° F vs Fresh	2	Fresh	2	Fresh
−30° F vs Fresh	5	Neither	>8	Neither
10° F vs −10° F	2	−10° F	1	−10° F

[1] Unavoidable circumstances prevented evaluation of cakes held at 0° F for two weeks.

At 10° F, significant differences in both texture and flavor were present by the end of the first week. Two weeks or more were required for the same degree of difference to occur at 0°, −10°, and −30° F, although significant differences were found at the end of one week in cakes stored at −10° F. Unavoidable circumstances prevented evaluation at 2 weeks of the cakes stored at 0° F so that the advantage shown for this temperature is probably not real. Significant differences probably would have been found if tests had been run after 2 weeks. Cakes exposed to 10° and −10° F were not reliably distinguished from one another until the fourth week, by which time a definite preference had also developed for the cake held at the lower temperature. The failure of the judges to demonstrate a consistent preference for the freshly baked cakes is a noteworthy feature, indicating that whereas detectable changes in flavor or texture had occurred, the changes were not necessarily regarded as objectionable.

As with the yellow layer cakes, an apparent softening and more moist-seeming condition of crumb developed gradually at 0° F or lower. Observations on softening were not consistent, however. Cakes held at 10° F became somewhat firmer and harsher. Many

of the judges commented favorably on a "more chocolaty" change in flavor of the frozen cakes during the relatively short storage periods used. No definite decline or change in character of aroma or flavor was discerned, in contrast to results with yellow layer cakes held for substantially longer periods. A number of the judges also commented that the crumb of the frozen cakes seemed to become darker and "more chocolaty" in appearance.

Chiffon cakes. Experiments on chiffon cakes were conducted in the same manner and at the same temperatures used for chocolate layer cakes. On a very general basis, chiffon cakes seemed to be benefited more by temperatures below 0° F than were the layer cakes (Table 3). Preference ratings generally favored the control cakes by a wide margin as soon as differences became significantly detectable.

Changes in texture seemed to be similar for all temperatures used, in contrast to layer cakes in which firming occurred at 10° F but not at lower temperatures. This difference may be accounted for by the fact that the nominal freezing point of chiffon cakes is about 16° F, whereas layer cakes freeze at 5° F or lower *(13)*.

Texture changes noted were a loss of resiliency by the crumb and an increasing crumbliness and harshness of texture that was characteristic for this type of cake. Flavor changes were similar to those for all the cakes, namely, a slow decline in intensity of flavor and aroma characteristic of freshly baked cake to yield an increasingly bland or predominantly sweet product. No stale or off-flavors were noted.

Angel food cakes. The experiments with angel food cakes were conducted at the same temperatures and in the same manner as those for the chocolate layer and chiffon cakes. Results, again, are summarized in Table 3. At −30° F consistently significant differences in texture did not appear within the 8 weeks of comparisons possible before the supply of stored cakes became exhausted. The stability of frozen angel food cakes at −30° F, in relation to their stability at all the higher temperatures, was improved to a greater extent than found for any of the other cakes.

Changes in texture were characterized by a relatively rapid loss of the unique toughness of the very soft crumb of freshly baked angel food cakes. During the early weeks, a number of judges commented favorably on the increased tenderness of the crumb. Later, however, this change became distinctly undesirable, resulting in a crumb that tended to be breadlike. Flavor changes were similar to those of other cakes and consisted mostly of a slow decline of flavor and aroma intensity. The flavor of salt residues (sodium chloride, potassium acid tartrate) became progressively more prominent than seems to be true for the salt residues in the other types of cake.

Pound cakes. Experiments with pound cakes were slightly different from those with the other cakes. The effect of −30° F was not studied, and cakes held at 10° F were compared with cakes held at 0° F, as well as with the freshly baked controls.

At all of the temperatures, significant differences in both flavor and texture between the stored cakes and fresh controls were reported by the taste panels upon the occasion of the first comparisons, which were after only four days in some cases and after one week in the others. This was expected for comparisons between frozen cakes and fresh cakes, in view of the previous demonstration that the mere act of freezing firms pound cakes sufficiently to permit reliable differentiation from fresh cakes *(13)*. With cakes held at 10° and 0° F and compared to each other, however, significant differences in texture were also found after only one week. Flavor differences were significant at the 5% point after one week. Very likely, the easily distinguishable differences in texture after such short periods strongly influenced the flavor judgments by the panels.

These results would seem to indicate that pound cakes do not freeze well, but this is not necessarily so. After 5 weeks at 0° or −10° F, the taste panels were no longer able to distinguish reliably between the frozen cakes and fresh cakes or between the frozen cakes held at these temperatures. This suggests that a favorable change in texture occurs after a few weeks at sub-freezing temperatures. (This possibility is being investigated in separate experiments to be reported later.) Cakes held at 10° F do not show this improvement, possibly because the nominal freezing point of the pound cakes appears to be about 2–3° F *(13)*.

The texture of pound cakes normally is much more dense and compact than those of other cakes, so that increased firmness may not influence acceptability very much. Early changes in texture were a rapid loss of crumb resiliency (which is only of a low order in freshly baked cakes) and a rapidly increasing crumbliness and mealiness. It is possible that the latter changes result in a more tender, softer *seeming* crumb without real differences in crumb compressibility. Flavor changes were generally similar to those of the other cakes.

Comparisons with day-old controls. Because most of the stability evaluations were made using freshly baked cakes, the results are somewhat unrealistic with regard to practical considerations. A limited number of further comparisons were therefore made using unfrozen control cakes that had been stored 24 hours at room temperature; day-old cakes are widely considered as still relatively fresh. A second reference point would thereby be furnished for orientation of commercial practice.

A number of each of the 5 types of cake were stored at 0° F for periods approximately equal to those that had been found to be required to produce significant differences from freshly baked control cakes. Comparisons were then made with unfrozen cakes that had been stored approximately 24 hr at room temperature after baking.

Although significant differences were detected between freshly baked yellow or chocolate layer cakes and similar cakes stored approximately a month at 0° F, no clear preference for either fresh or stored cakes was expressed by the taste panels. The cakes stored for this length of time at 0° F, however, were quite clearly superior to the day-old cakes (Table 4).

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TABLE 4

Time in weeks to first significant difference (5% point) between cakes held at 0° F and fresh or day-old unfrozen cakes

Cake type	Fresh control		Day-old control	
	Time	Preference	Time	Preference
Yellow layer	(4)[1]	Neither	5	Frozen
Chocolate layer	3	Neither	5	Frozen
Chiffon	1	Fresh	2	Day-old
Angel food	2	Fresh	3	Day-old
Pound	<1	Fresh	5	Day-old

[1] Estimated from results in Tables 1 and 2.

Chiffon cakes stored at 0° F for one week were clearly inferior to freshly baked cakes but at least as good as day-old unfrozen cakes until the end of the second week. Comparable periods for angel food cakes were 2 and 3 weeks, respectively. As noted previously, freshly frozen pound cakes are immediately inferior to unfrozen fresh cakes. After approximately 5 weeks at 0° F, however, they were no longer judged superior to the day-old cakes.

Despite the relatively short periods required for demonstration of significant changes between even day-old cakes and frozen cakes held at 0° F, it must be clearly recognized that the quality of the frozen cakes is still quite high. Preference ratings, especially in such relatively small numbers as obtained in the present study, must be interpreted with caution. Moreover, differences clearly discernible under more or less ideal experimental conditions are often undetected in commercial practice. In other words, the time limitations on quality observed in the present study are possibly a little austere and could be liberalized somewhat in translation to trade practices. Nevertheless, it is clearly evident that soft cakes are not as immune to quality deterioration during frozen storage as might be assumed from their tolerance to variations in rate of freezing or defrosting. Careful consideration must always be given to many factors when freezing is applied to cakes commercially, and each type of cake should be considered separately.

SUMMARY AND CONCLUSIONS

Stability at several temperatures was determined for frozen yellow layer, chocolate layer, angel food, chiffon, and pound cakes by means of taste panel comparisons with freshly baked and day-old unfrozen cakes.

Texture changes in the frozen cakes were generally detected before changes in flavor. Principal texture changes were loss of original crumb resiliency and increases in crumbliness and harshness. Each type of cake exhibited texture changes of a somewhat characteristic nature. Flavor declined gradually to yield increasingly bland products. No characterizable stale or off-flavors were encountered.

Yellow and chocolate layer cakes exhibited relatively good stability at 10° F and greatly improved stability at 0° F. However, little gain in stability was obtained at −10° and −30° F. Layer cakes seemed to soften and become more moist at 0° F or below. This apparent softening eventually deteriorated into an unacceptable gumminess or pastiness. Layer cakes were by far the most stable of the cakes studied.

Pound cakes at temperatures of 0° F and below very rapidly developed differences in texture but the initial loss of resiliency and increased firmness later appeared to become overshadowed by increased tenderness as the cake became more crumbly.

All types of cake showed highly significant differences from freshly baked cakes within four weeks at 0° F. Even after significant changes had occurred in the frozen cakes, however, their quality was still quite good. In all cases, they were superior to day-old unfrozen cakes.

Acknowledgments

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Heat Transfer in Hot Fat Cooking*

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MANY FOOD PRODUCTS are cooked or processed in hot fat. This process is sometimes termed "deep fat cooking." Usually three coincidental effects are produced by deep fat cooking: (1) The process of cooking per se, i.e., causing the chemical changes to occur that convert the product from its natural raw state to a cooked product; (2) the evaporation of moisture from the product, and (3) the absorption of fat into the product, which usually adds a desirable flavor. The relative importance of these three separate functions varies with the product. Among the more widely accepted deep fat cooked products are potato chips, French fried potatoes, doughnuts, fish sticks, fried chicken, diced meat patties, edible nuts, fried fruit pies, corn meal items such as "Fritos" and "Hush Puppies."

Potato chips form probably the largest volume food item processed by deep fat cooking. Potatoes have a very high water content, with approximately 17% potato solids to 83% water. In the cooking of potato chips there is a very high heat demand to supply the latent heat of vaporization to boil off the large amount of water. As 100 lb of potatoes will yield approximately 17 lb of potato solids, it is obvious that 83 lb of water will have to be evaporated, which means that approximately 83,000 Btu's must be made available in order to produce 17 lb of potato solids. The fat content of potato chips will vary from 38–42%. Therefore, the fat absorbed by the chips becomes an important food component and also contributes substantially to the flavor. The amount of heat required to cause the chemical change necessary to cook the potato is relatively small compared to the total heat load.

The opposite condition obtains when cooking edible nuts, such as pecans, peanuts, etc. Very little moisture is vaporized because the initial moisture content of the product itself is low. Due to the high fat content of the product, little or no change occurs in the fat content; therefore, the major function of the immersion of the product into the hot cooking fat is to cause the chemical changes required in order to actually cook the product. Between these two extremes, there are many combinations of heat load demand in deep fat cooking.

Regardless of whether or not a considerable proportion of the fat is absorbed by the material being cooked, the essential function of deep fat cooking is to supply heat to the product at a rate, under controlled temperature conditions, that produces the best over-all results. As the product absorbs heat from the cooking fat, it is necessary to continuously replenish the heat given up by the fat.

Within the range of practical and economical processes, we can consider that heat is to be transferred to the fat from a heated surface with which the fat is in direct contact. The rate at which heat is transferred follows the laws of conventional heat transfer engineering. These laws show that the rate of heat transfer varies with the difference in temperature between the hot surface and the fat and also with the rate at which the heated film of fat is removed from the hot surface and replaced with a film at lower temperature. There are many other factors which enter into the equation for over-all heat transfer rates, such as thermal conductivity of the hot surface material, thermal conductivity of the fat, viscosity of the fat, etc.

Cooking fats are susceptible to heat damage, and this damage occurs at an increasing rate as the temperature of the fat is increased. The degradational changes occurring in cooking fats exposed to elevated temperatures are (1) hydrolysis, (2) polymerization, (3) stability, (4) discoloration, and (5) flavor. Hydrolysis involves the splitting of the fat into its component fatty acids and glycerol. Fresh shortenings usually contain less than 0.10% free fatty acid, but if the fat is heat-damaged the free fatty acid content may reach 5%, which is very undesirable. As the smoke point of the shortening is inversely proportioned to its free fatty acid content, the high free fatty acid value causes excessive smoking.

DISADVANTAGES OF THE CONVENTIONAL METHOD

The conventional method of deep fat cooking requires a carbon or stainless steel tank, kettle or vat to contain the cooking fat, with a gas or oil-fired furnace immediately beneath it. The disadvantages of this arrangement are obvious. The most important are (1) insufficient heat transfer surface requiring a large temperature difference in order to transfer the required heat load through the relatively small area of heat transfer surface available; (2) destructively high film temperatures in the film of fat in contact with the heating surface; (3) lack of proper temperature control due to the large thermal flywheel capacity of the furnace refractories which continue to radiate heat for a prolonged time after the burners have been turned off; (4) extremely low thermal efficiency due to furnace volume usually being too small, therefore the heat release rate per cubic foot of furnace is far too high for efficient combustion. This condition coupled with the inadequate area of heat transfer surface results in stack temperatures sometimes reaching more than 1,600° F; (5) the fire hazard of having the heater in the immediate vicinity of combustible cooking fat. This is a serious handicap, as evidenced by the many plants that have been destroyed by acci-

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dental ignition of cooking fat by the heater, and (6) the physical discomfort and poor working conditions in the food preparation area caused by the proximity of the high heat capacity heater in the work area.

THE SMITHERM METHOD

The Smitherm method of indirect heating of cooking fats was developed in order to eliminate the inherent defects in the conventional method. Essentially, the Smitherm process requires a heat generator with a combustion chamber of adequate proportions to provide heat release comparable to the best modern practice in boiler design. The heat transfer, or absorbing surface, in the generator is composed of steel tubes or pipes through which is circulated a high-boiling liquid heat transfer material.

There are other methods of indirect heating of the cooking fat, such as steam, Dowtherm or aromatic oils. Steam is obviously the most convenient and universally accepted source of heat for most industrial problems but in order to obtain the required temperature it is necessary to use very high steam pressure, around 400 pounds gage pressure. This is far beyond the range of industrial steam boiler plants, therefore, steam has been discarded as being impractical. Dowtherm in the vapor phase does provide a high temperature but any heating media used in the vapor or gas phase presents difficulty of control, condensate return systems, et cetera, that add to the complexity of the system and seriously reduce the flexibility of operation. Dowtherm vapors are very difficult to confine because, due to the low viscosity of the Dowtherm gas, it is practically impossible to keep a system leak tight. Aromatic oils have a high boiling point and from this viewpoint they are acceptable, because they can be used at atmospheric pressure. Both the aromatic oils and Dowtherm have serious disadvantages in that they are flammable: if a leak should occur in the heater or boiler a serious fire could result. The aromatic oils have one more disadvantage in that scale or carbon formation can occur in the boiler or heater tubes due to excessive or local overheating.

The transfer liquid is pumped through the shell side of a conventional shell and tube heat exchanger and returned to the generator. The fat is removed from one end of the cooker by means of a suitable pump and circulated through the tubes of the shell and tube heat exchanger and then returned to the opposite end of the cooker. Although any high boiling heat transfer liquid may be used in the heat generator, it has been found that Aroclor 1248, a chlorinated biphenyl, is the most satisfactory material presently available. It is nonflammable, low in cost, has a low viscosity at operating temperatures, is noncorrosive, and has reasonably good heat transfer physical properties.

The heat generator is operated as an open vented system with an open expansion tank located above the highest point in the system and connected to the suction side of the circulating pump. This arrangement is similar to a forced hot water residential heating system and is made possible by the high boiling point of the heating liquid. Figure 1 shows a conventional potato chip cooking machine, and it is to be noted that the furnace gases have little opportunity to transfer heat to the bottom of the kettle. The hot refractory furnace lining may give off heat at a rate of 50,000 Btu/sq/ft/hr. Therefore, a furnace having 75 sq ft of hot face surface will radiate energy at a rate of over 3,000,000 Btu/hr. It is obvious that any form of temperature control that would only change the rate of flow of fuels through the burner would have little or no effect in controlling temperature in the cooking fat within the time intervals required for accurate temperature control.

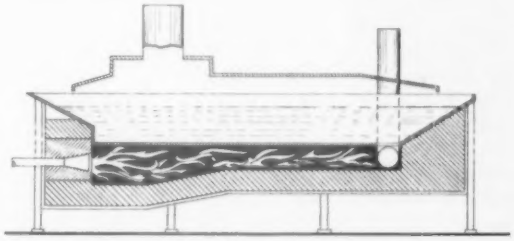

Figure 1. Conventional potato chip cooker.

A DIRECT-INDIRECT HEATING METHOD

In an attempt to eliminate some of the operational hazards and disadvantages of direct-fire method of heating cooking fats, a "direct-indirect" method has been developed. This consists of a boiler or heater through which is circulated the cooking fat from the kettle through the heater and back to the kettle. This does remove the fire hazard danger from the cooker but does not reduce the possible damage to the cooking fat because the fat is circulated through the boiler tubes and is subjected to direct heat of the furnace. As the cooking fat itself is highly flammable, this also creates an additional fire hazard.

Figure 2 shows in simplified form a conventional Smitherm potato chip cooker. It is to be noted that, although this drawing only shows one cooker supplied by one heat generator, any number of cookers can be

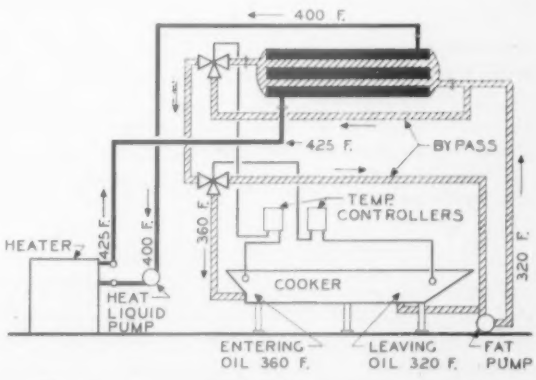

Figure 2. A conventional Smitherm potato chip cooker.

operated from one common heat supply system, and each cooker can be operated at its own controllable temperature, regardless of the operating temperatures of the other cookers.

Potato chips have been used as a typical example because they are produced in large volume. Two of the requirements of cooking potato chips are that (1) the temperature of the fat entering the cooker must be held to any preset temperature and best results are obtained when this temperature is held within very narrow limits, and (2) that a predetermined temperature gradient be maintained throughout the length of the cooker. Both of these values are influenced by the variety and specific gravity of the potatoes processed. A typical example is an inlet temperature of 360° F and an exit temperature of 320° F.

Figure 2 shows an arrangement in which the heating liquid is circulated through the heater, then through the shell side of the heat exchanger and returned to the heater. Acceptable values for temperature of the heating liquid would be 425° F both for leaving the heater and for entering the heat exchanger to supply heat to the cooking fat circulated through the heat exchanger, and 400° F for returning to the liquid heater.

In order to control the temperature of the fat entering the cooker, a temperature sensing element is located in the cooker at the infeed end, and this element acts through a conventional temperature controller to continuously adjust a three-way modulating, or mixing, valve with the function of permitting some of the cooking fat to pass through the tubes of the heat exchanger and some of it to bypass the exchanger. The resulting mixture reaches a temperature called for by the setting of the temperature controller.

In this system, the temperature of the heating liquid in the shell side of the heat exchanger remains practically constant and the cooking fat temperature is controlled by the ratio of fat that passes either through or around the exchanger. In order to maintain the preset temperature gradient or temperature drop throughout the length of the cooker, a second temperature sensing element is placed in the cooker near the exit, and this in turn controls the volume of cooking fat that enters the cooker. If the rate of raw potato slices entering the cooker is increased or decreased, the demand for heat is immediately changed in the same ratio. Therefore, to maintain a fixed exit temperature, more fat must be passed through the kettle when the rate at which raw potatoes are fed into the kettle is increased. The result of this controlled combination is that regardless of fluctuation in rate of feeding product into the cooker, the inlet and exit temperature of the cooking fat always remains at the predetermined values.

A MODIFIED CONTROL CIRCUIT

Figure 3 shows a modification in the control circuit that has advantages over the previously mentioned control circuit for some conditions and products. The major difference is that all of the cooking fat passes through the tubes of the heat exchanger, therefore

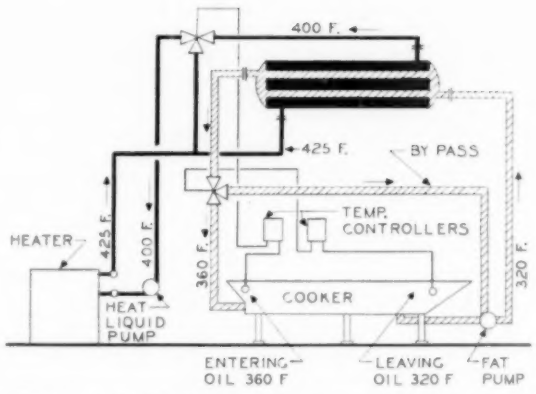

Figure 3. Modified control circuit: all cooking fat passes through the tubes of the heat exchanger.

maintaining a high and uniform velocity of fat. This prevents the settling out of fines or any other material that might have a tendency to settle out in the heat exchanger, with a reduction in velocity of the fat.

Temperature control of the fat is obtained through by-passing the heating liquid around the heat exchanger. The two important differences are that under light load conditions the average temperature of the heating liquid in the heat exchanger is much lower than it would be under conditions shown in Figure 2 for the same load and that under light load the temperature of the fat leaving the heat exchanger is the same as the temperature of the fat entering the cooker. Whereas, under conditions shown in Figure 2, the temperature of the fat leaving the heat exchanger could approach the temperature of the heating liquid, which would be much higher than the temperature of the fat after it passes through the three-way mixing valve. Theoretically the control circuit shown in Figure 3 would introduce a time lag in control due to the thermal flywheel capacity of the heating liquid in the heat exchanger, but in practice this has not proved to be important thus the advantages of this method far more than offset the theoretical disadvantage.

Figure 4 shows another modification in detail of the Smitherm process. This alternate detail of construction of the kettle provides additional heat for the

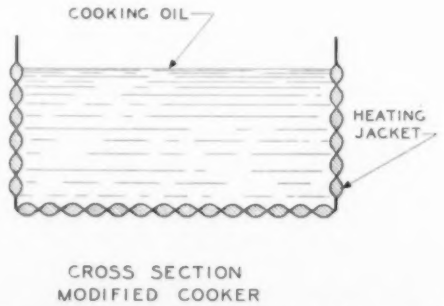

Figure 4. Showing jacketed spaces, a part of the kettle itself, through which the heating liquid is circulated.

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kettle by circulating the heating liquid through channels, or jacketed spaces, that are a part of the kettle itself. For products requiring a high heat capacity, this jacketed kettle construction provides supplementary or additional heat beyond what is supplied by the external shell and tube heat exchanger. For those products with a relatively low heat demand, it may not be necessary to provide an external heat exchanger.

Whenever an external heat exchanger is used, it is obvious that there must be a difference in temperature of the cooking fat between the inlet and exit of the kettle because it is this difference in temperature that is returned to the fat as it circulates through the heat exchanger. In cooking those products that require a minimum temperature gradient, or difference, throughout the length of the kettle, this supplementary heated kettle bottom tends to reduce the thermal gradient in the cooking fat.

A CURIOUS PHENOMENON

In cooking potato chips, potatoes are first peeled, then cut into transverse slices approximately $\frac{1}{20}$th of an inch thick, and the slices are dropped into hot cooking fat at a temperature of approximately 360° F. As this temperature is approximately 150° above the boiling point of water, and as the slices have a high ratio of surface to volume, heat transfer occurs at a very high rate. When it is realized that the distance from the surface to the center of the slice is only $\frac{1}{100}$th of an inch, it is apparent that the entire slice is heated rapidly. A peculiar phenomenon occurs which has probably not been previously observed or recognized. Steam or water vapor is generated within the structure of the potato slice at a rate that is so great that the steam expands and builds up sufficient pressure to drive out through the fibrous structure of the potato many small droplets of water that are actually in the liquid state. Even though these minute droplets are surrounded by fat at a temperature of 360° F, greatly in excess of the normal boiling point of water, they remain as droplets as in an emulsion.

The droplets are of such small size that their surface tension is greater than the internal rupturing force caused by the high temperature. Due to the greater density of these droplets, they tend to settle and flow along the bottom of the kettle. If the fat removal pump is located so that there is little or no positive head on the suction side of the pump, due to the reduced pressure in the suction near the eye of the pump impeller, and possibly to the violent turbulence of agitation that occurs at this point, the water droplets are ruptured, releasing a large volume of water vapor in the pump cavity causing vapor lock and completely stopping the pumping action. This difficulty does not occur if a pump is used having an impeller with the capacity for handling rather large volumes of gas commingled with the liquid passed through the pump. The "hot bottom" type of kettle construction, in which the heating liquid would flow counter to the direction of the cooking fat so that the highest temperature heating liquid would be at the discharge end of the kettle, would tend to eliminate this difficulty by raising the temperature of the fat to a point whereby a large percentage of the small droplets would explode and release water vapor.

A SHELL AND TUBE HEAT EXCHANGER

Figure 5 shows a detail construction of a shell and tube heat exchanger that has proved to be very practical. The conventional shell and tube heat exchanger consists of a tube sheet that supports and seals each end of the tubes carrying the fat. Rarely does a leak occur where the tubes are secured into the tube sheets, but there is a remote possibility that a leak could occur at this point. In order to provide complete protection and to eliminate any physical possibility of intermingling of the heating liquid with the cooking fat, the double tube sheet construction as shown in Figure 5 has been used. Actually, this has added very little to the cost of heat exchangers. It is to be noted that if a leak occurs from the cooking fat area, around the end of a tube, the leak flows to atmosphere. The same applies to tubes where they pass through the inner tube sheet that confines the heating liquid. If the heating liquid leaks, it always leaks to atmosphere.

Another point of practical importance in the use of deep fat cooking is reducing the temperature of the cooking fat in the system as soon as possible after stopping the cooking operations. With the Smitherm system, a simple heat exchanger, usually consisting of a pipe sleeve placed around a long straight run of pipe carrying the cooking fat, permits cooling water to be introduced so that by operating the fat circulating pump for a few minutes the temperature of the cooking fat can be reduced to any desired level almost immediately. If necessary, it can be left in the kettle as a storage means.

In cooking potato chips, a total heat requirement or heat load is the sum of the sensible heat required to heat the make-up fat from room temperature (or, in the case of hydrogenated fats, from some higher temperature) to the temperature of the fat in the cooking kettle plus the sensible heat required to heat the raw

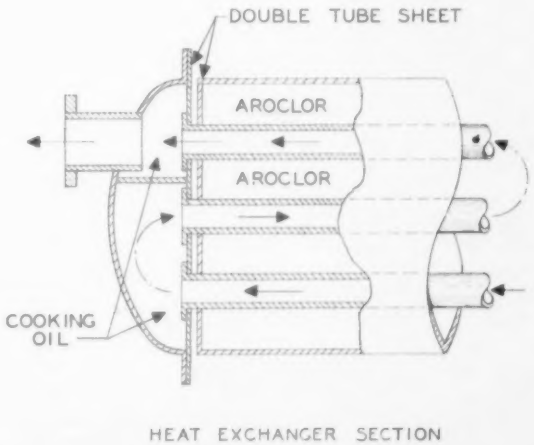

Figure 5. Shell and tube heat exchanger.

potato slices from room temperature to the boiling point of water plus the latent heat of vaporization required for the amount of water boiled from the product plus the sensible heat of the potato solids from the boiling point of water to the exit temperature of the cooking fat.

A slight difference in the specific gravity of the raw potatoes makes a large difference in the ratio between potato solids and water in the potatoes. Figure 6 shows the relation between potato solids and the

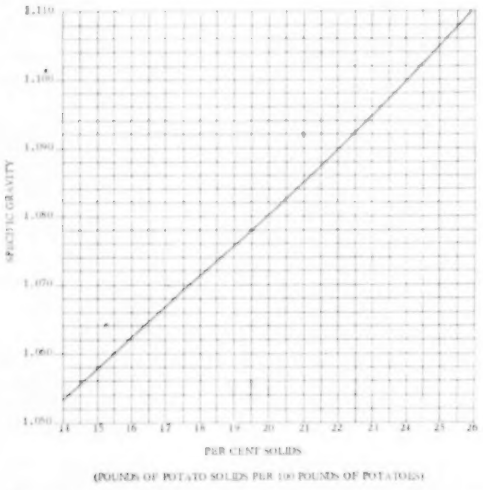

Figure 6. Relationship of specific gravity versus solids of white potatoes.

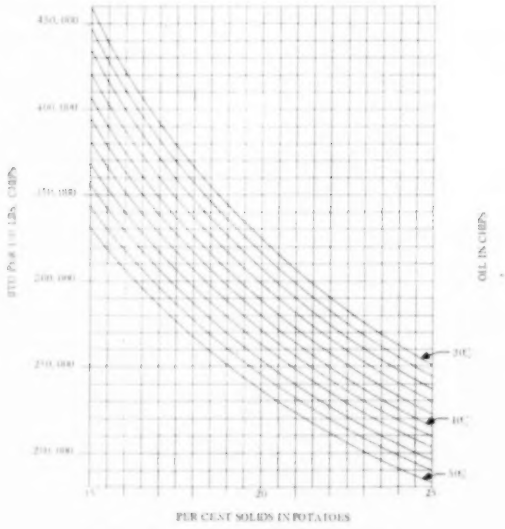

Figure 7. Heat required to cook chips.

specific gravity of the raw potatoes. Figure 7 is a family of curves showing the total heat required to produce 100 pounds of finished potato chips. The variables are the specific gravity of the potatoes and the final fat content of the finished chips. For estimating purposes, it can be assumed that 350,000 Btu's are required to produce 100 pounds of finished potato chips under average conditions.

As the Smitherm process is entirely confined to the method of heating the fat, it can be applied to any type of cooker, including the conventional direct-fired type. The only change necessary is to provide means of introducing and distributing the heated fat at the entrance end of the kettle and providing discharge connections to the opposite end so that the fat can be removed by a suitable pump and recirculated through the heater. The previously used burners or heating equipment can either be left in place or removed.

SUMMARY OF ADVANTAGES

Summary of the advantages of the Smitherm indirect method of hot fat cooking are:

(1) Substantial reduction in heat damage to the cooking fat due to the fact that the fat cannot come in contact with a high temperature surface.

(2) Product improvement due to reduced rate of increase of free fatty acids, therefore adding shelf life to the product.

(3) Precise temperature control and means for accurately controlling both the inlet and the outlet temperature of the fat regardless of fluctuations in product load.

(4) Substantial fuel savings are obtained because the heat generator or boiler is designed with sufficient furnace volume and adequate heat transfer surface, therefore the over-all efficiency compares favorably with the best steam boiler performance.

(5) Multi-cooker operations. Where more than one cooker is required in the same plant, one heat generator can be used to supply as many cookers as may be needed and each cooker can be operated at its own temperature requirements, which may be different from the other cookers.

(6) Safety and comfort. The system is entirely safe because the heating liquid is nonflammable and the system operates at atmospheric pressure, using the well known principle of an open vented expansion tank. Comfort conditions in the cook room are greatly improved because the major source of heat release and discomfort has been eliminated.

(7) Increased capacity. It has been proved that at least 50% more production can be obtained from the same size cooking kettle compared to the maximum production obtained with direct fire cooking.

Problems in the Preparation and Handling of Hot Vended Canned Foods*

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THE VENDING OF HOT FOODS in cans is a comparatively recent innovation in the food service industry. It bears watching by food and packing technologists since much of the success of this method of food distribution will depend upon their efforts. Briefly defined, hot vending refers to the use of coin-operated vending machines equipped with facilities to heat certain specially prepared canned foods to serving temperatures (140–150° F). The advantage to the purchaser is that he has the major component of a hot meal, ready for immediate consumption.

Hot vended canned foods fulfill a special need in that workers, students, and travelers can have access to a quick and convenient hot meal in locations where the volume of business is too small to support regular cafeteria or luncheounter facilities. From the consumer's standpoint, hot vended canned foods must be appealing, appetizing, nourishing, of sufficient variety to avoid monotony, warmed to a desirable serving temperature and yet not too hot to be handled. In addition, they must be convenient to open, capable of being handled in vending machines in a sanitary manner, and economical. The vending of hot canned foods is usually coupled with hot or cold beverage and sandwich venders as well as pastry venders in order to round out a complete meal for the consumer. Typical products include soups, chili, meat stews, pork and beans, ravioli, spaghetti with meat balls, chicken noodle dinner, beef goulash, and franks and beans packed in cans ranging in capacity from 6 to 8¾ oz.

Background. During the latter part of 1955, the food service industry experimented with a few coin-operated dispensing machines for vending hot foods in cans. General acceptance of this method of serving food is indicated by the fact that by the end of 1956, 6,800 machines sold 30 million hot meals in cans; in 1957, 15,000 machines sold 50 million canned food dinners valued at $15.5 million; and by the end of 1958, 17,100 machines vended 75 million canned food dinners, valued at approximately $18.5 million. The success of hot vended canned food has created considerable interest, particularly in the canned foods industry. This is not surprising since hot vending is not directly competitive with the ordinary marketing of canned foods. Moreover, it offers a new outlet for processed food products.

However, the preparation and handling of hot vended canned foods present problems of direct concern to the canning industry and to the acceptance of such canned foods in general. Broadly, these include: (1) *bacteriological* aspects of preparation, storage and handling of hot vended canned foods; (2) effect of high temperature storage in vending machines on *product quality;* and finally (3) *consumer acceptance* of hot vended canned foods.

BACTERIOLOGICAL ASPECTS

Storage of canned foods for prolonged periods of time in vending machines at a serving temperature of approximately 150° F has introduced bacteriological problems not heretofore of primary concern to the canning industry. The canning industry has not been seriously troubled in the past with thermophilic bacterial spoilage, as this is usually avoided by careful control of cooling operations and storage temperatures. Operating temperatures in vending machines, however, are conducive to the growth of thermophilic spoilage organisms, both gas-forming and flat sours, in otherwise commercially sterile products.

Thermophilic spoilage manifests itself either as "swells" or "flat sours." The degree of susceptibility of a product to bacterial spoilage depends principally on acidity: the lower the acidity (higher pH), the greater the susceptibility to spoilage. Thermophilic anaerobes (gas-producing) are generally considered as having a higher resistance to heat than putrefactive anaerobes but not as high as thermophilic flat sours. Although some benefit might be realized from increasing the heat process to control spoilage from thermophilic gas producers, process control of flat sour organisms would excessively degrade the quality of the product *(1)*.

Sources of trouble. The first hot vended canned food machines had a separate pre-warming storage area with temperatures ranging between 120–130° F and a main heating or dispensing area maintained at 140–160° F. It was possible for cans to remain in the pre-warming area for 3 days and then in the main heating area for a similar period of time before purchase. We strongly recommended that these pre-warming areas be eliminated, and that the main dispensing area be held at not less than 150° F, to significantly reduce the probability of thermophilic spoilage. Many vending machine manufacturers have since adopted this suggestion.

Sources of thermophilic organisms causing spoilage may also be found in canning ingredients or in canning equipment which is allowed to remain in the thermophilic temperature growth range during operation and shut-down periods. The use of thermophilic-

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free cereals and sugars is therefore extremely important for foods intended for sale through vending machines. Proper cooling of the product after processing and strict adherence to good operating and sanitation practices should also help considerably to eliminate the possibility of thermophilic spoilage *(2)*.

Sanitary aspects. The sanitary aspects of serving hot vended canned food also merits consideration. When this method was first introduced, certain local public health officials objected to the continued use of can openers placed alongside the vending machines, without some method of sanitizing them during use. Attempts were made to develop a can opener utilizing a detergent wash and water rinse after each use. Excessive costs deterred its adoption. We spent considerable time and effort investigating various other types of can openers of a sanitary design as well as new and different means for opening cans. To date, however, we have had limited success in achieving our objectives. At present, the most practical solution has been to use regular wall type can openers, which are changed on a regularly scheduled basis, and to have constant surveillance by the service organizations regarding general cleanliness of the vending machines and can opening areas. In general, there has been no action on a national level regarding the sanitary aspects of hot vended canned food. As a matter of fact, canned foods were specifically excluded from the Sanitation Ordinance and Code developed by the U. S. Public Health Service in 1957 for the vending of foods and beverages *(3)*.

PRODUCT QUALITY

Maintaining product quality is a major problem because of the severe storage conditions encountered in the vending machines. Flavor deterioration and product degradation vary greatly when these foods are held at 150° F. This in-machine storage requirements of the different service organizations (vendors) also varies; thus food processors should not overestimate the resistance of their products to deterioration at elevated temperatures and should formulate products with this in mind.

Our investigations have shown that flavor, appearance, and texture of the product can all be affected by the severe storage conditions in the vending machines. Generally, products such as chili, beef stew, pork and beans and related products are least affected; products containing large amounts of starchy particles or tomatoes, such as ravioli, spaghetti and sauce, etc., are usually more adversely affected. With products such as ravioli, the large starchy particles tend to absorb all the liquid from the sauce, severely affecting color, appearance, texture, and flavor. Products with large amounts of tomato sauce tend to pick up a scorched bitter flavor. As would be expected, the intensity of these changes increases with time, as illustrated by the data presented in Table 1. Product acceptability tests were carried out at the serving temperature (150° F) for all samples. An expert panel of 8 persons (both men and women) was used. The rating scale used is given in Table 1. No explanation can be offered for the apparent increase in product acceptability of beef stew stored at 150° F, other than would be expected in the normal variations in product evaluation work.

TABLE 1

Comparative product acceptability for canned foods stored at 70° F and 150° F for five days

Product	Product acceptability	
	70° F storage	150° F storage
Beef Stew	56	61
Brunswick Stew	62	57[1]
Chili	64	62[1]
Spaghetti and Tomato Sauce	70	50[1, 2]
Cheese Ravioli	73	20[3]
Macaroni and Beef in Tomato Sauce	73	45[1, 2]

Rating scale: 80, excellent; 70, very good; 60, good; 50, average; 40, fair; 30, borderline; 20, unmerchantable.
[1] Slight scorched tomato taste.
[2] Less satisfactory texture, slight darkening.
[3] Extremely poor texture and color, scorched taste, product unacceptable.

The effect of storage temperature on the pH of various products stored for 5 days, as shown in Table 2, is also of interest.

TABLE 2

pH changes in various products stored at various temperatures for five days

Product	pH		
	70° F storage	130° F storage	150° F storage
Brunswick Stew	5.25	5.10	5.00
Beef Stew	5.70	5.50	5.35
Chili	5.60	5.45	5.35
Spaghetti Lunch	5.25	5.15	4.95
Beans with Barbecue Sauce	5.20	.....	5.00

Although the results of the above tests might indicate a relationship between pH and product acceptability, no attempt has been made to correlate the data at this time. For that matter, it would be surprising if such a correlation existed in such highly buffered solutions. It can be concluded, however, that chemical degradation changes are taking place more rapidly at the elevated storage temperatures than at 70° F.

Although the storage requirements imposed by some vendors are very severe (e.g., 5 days at 150° F), products seldom have to withstand such treatment in most vending machines. The average vending machine holds about 150 cans, divided among 4–6 product varieties. If any product fails to turn over in 2 to 3 days, it would almost have to be eliminated for economic reasons alone.

In view of the fact that storage at 150° F is the most detrimental factor in hot vending canned foods, it is imperative that canners establish storage limits and recommendations for their products and insist that vendors follow these specifications to insure acceptability from a quality standpoint. Our investigations indicate that maximum storage of 2–3 days is the most satisfactory except for certain products of exceptional stability. In some instances, product reformulation may be necessary to overcome flavor and other quality changes even for storage periods as short as 2–3 days at 150° F.

CONSUMER ACCEPTANCE

When this method of feeding was first considered, it was felt that much selling would be necessary to get people to eat directly from cans. Although this has not been a major objection where most consumers are men, the fact that some consumers consider it objectionable has not been overlooked. In some cases, to abate objections, special cups are provided. Food from the cans can be transferred to the cups, thereby eliminating the problem. Eating directly from the can is the preferred procedure, naturally, from an economic standpoint.

Holding the hot can during eating is another problem in the acceptance of hot vended canned foods. Although at present most machines supply napkins to protect the hands, most operators consider this unsatisfactory. They feel that the holding device should be an integral part of the container. We originally suggested a thicker label, possibly with an asbestos backing. One of the major suppliers of canned foods for vending machines is now distributing cans with a rather heavy, porous paper under the regular printed label. This double label is an improvement over the usual single label, providing protection as an integral part of the container. Another supplier is now preparing to use an asbestos backed label for the same purpose.

SUMMARY

Maintenance of product quality during high temperature storage in the vending machines is of major concern to both the processor and vendor. The processor must determine acceptable quality storage life for his products and reformulate if necessary in order to maintain quality levels comparable to other methods of handling and serving foods.

The food service industry also recognizes some problems in this type of merchandising—particularly, the sanitation of vending equipment and can openers. Sanitary maintenance of equipment and frequent changing of can openers on a regular schedule have done much to alleviate this problem. Consumer acceptance of both the product and method of consuming (direct from cans) is a joint problem of the food service industry and food processors. We strongly recommend that food processors do everything possible to develop a wider variety of products as well as to improve existing products to withstand high temperature storage and retain high quality to help overcome "lower quality" and "no variety" objections or complaints. Although objections to eating from cans have been abated in some instances by supplying transfer cups, a more practical and economical solution might lie in the design and development of eye-appealing cans, with attractive lithography or labels, intended specifically for this outlet—a challenging problem for the packaging technologist.

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The Influence of Low Level Gamma Irradiation, Antibiotic Treatment, Storage Temperature and Vacuum Packaging on Flavor and Bacterial Changes in Cured Bacon[a]

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(Manuscript received July 31, 1959)

COMBINATION METHODS of preservation for extending the shelf life of meat products appear to offer numerous advantages over the use of a single method *(1, 2, 3)*. The objectives of the present study were to evaluate storage stability and bacterial changes in cured bacon subjected to different handling and storage conditions after slicing.

MATERIALS AND METHODS

The bacon for our experiments was selected from the processing line of our Ottumwa Plant. The sliced bacon packages were numbered consecutively from the shoulder to the flank end of the same belly to minimize variation in the fat-lean ratio between treatments.

The antibiotic used in this study was oxytetracycline and the bacon slices receiving antibiotic treatment were individually dipped in a 500-ppm Biostat solution (100 ppm OTC). The slices were allowed to drain prior to packaging. The yield of sliced bacon out of the OTC dipping solution averaged 110%.

To study the effect of the vacuum packaging *versus* packaging in air approximately one half of the pouches were sealed in the presence of air. The remaining pouches were sealed under 27–29 in of vacuum. The packaging film construction was pouches made from saran-coated mylar laminated to polyethylene.

The bacon was shipped for irradiation to the Materials Testing Reactor at Idaho Falls, Idaho. Since freezing alters the flavor characteristics of bacon, the pouches were packed with 30 lb of a liquid refrigerant in an insulated shipping container to provide temperatures normally used with this product. This gave an in transit temperature of 32–38° F on both the controls and packages to be irradiated. The product was irradiated at a level of 200,000 rads.

Storage of the product after return from the MTR was at three different temperatures—40–50° F; 36–38° F; and 28–32° F—until evaluated bacteriologically and organoleptically. Samples were removed aseptically from the packages and total bacterial counts were determined by plating on Tryptone, Glucose, Yeast Extract Agar and incubating at 35° C for 48 hr. Counts are reported as the average of duplicate plates. Our taste panel members were selected by their performance over a period of years for their ability to evaluate the product for high quality, characteristic flavor, and consumer acceptance. To evaluate the flavor the following simple scoring system was used with appropriate values for each rating:

Flavor description	Score
Above Average	3.0
Average	2.0
Below Average	1.0

[a] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, QM Research and Engineering Command, U. S. Army, and has been assigned number 985 in the series of papers approved for publication.

RESULTS AND DISCUSSION

Samples were removed from storage at predetermined intervals and scored for flavor. A taste panel (minimum of 6 members) rated each sample and the average scores are presented in Table 1. Only a slight difference in flavor was detectable in the control bacon after shipping it to the irradiation site and back to our laboratories. The higher initial scores on antibiotic treated bacon are probably due to differences in bacon rather than treatment variations. The "Fresh" and "After Shipment" ratings are given three times (at 40/50, 36/38 and 28/32) to clarify flavor changes at each temperature. They are not three separate ratings.

The irradiated bacon scored below average in flavor and the irradiation flavor was readily discernible on the coded samples. The packages of bacon irradiated and stored under vacuum were slightly superior to the air packages. Irradiation at the 200,000 rad level lowered the bacterial count on the product as indicated in Table 2. Each count was made on a different package of bacon therefore minor differences in counts are not significant.

The bacon dipped in an antibiotic[b] solution (100 ppm OTC) scored as high as the control at the beginning of the experiment (after shipment) but after two weeks a definite bitterness was observed in these samples. The bitter after-taste was also observed in the combination antibiotic-irradiated bacon but it was partially masked or covered by the irradiation flavor.

The combination treatment of antibiotic and irradiation was superior for controlling bacterial growth at all aging temperatures. The effectiveness of the combination treatment shown in Table 2 appears to be greater than the total of individual effects.

Vacuum packaging was superior to air packaging for product protection as measured by bacterial counts, flavor ratings, maintaining color and reducing irradiation flavor. Vacuum packaged samples had higher flavor ratings at any given storage age and temperature than any of the other treatments.

Holding temperatures had a marked influence on the flavor and bacterial changes in the product. The lower storage temperature (28–32° F) was best and even at this temperature the bacon started losing flavor acceptability at 5–6 weeks. Unacceptable flavor

[b] The food grade antibiotic "Biostat" made by Chas. Pfizer & Co. was used in this study.

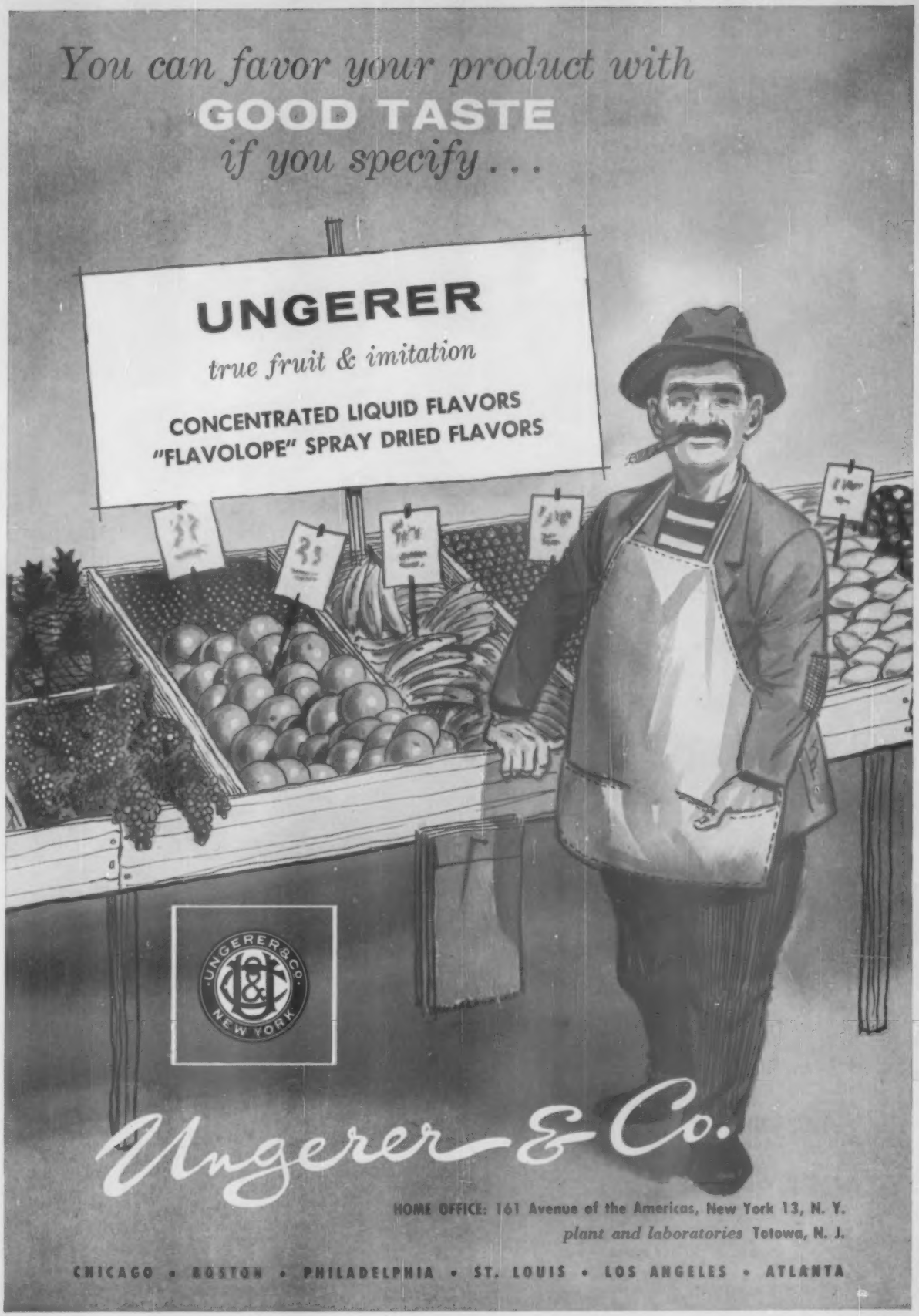
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TABLE 1

Bacon flavor scores[1] at different time intervals and storage temperatures

Aged	Air				Vacuum			
	Control	Irradiated	Antibiotic	Antibiotic irradiated	Control	Irradiated	Antibiotic	Antibiotic irradiated
At 40/50° F								
Fresh (untreated)	2.0		2.7		2.0		2.3	
After shipment	2.0	1.0	2.4	1.6	2.2	1.2	2.2	1.8
Aging: 2 weeks	1.6	1.0	1.0	1.0	2.0	1.2	1.0	1.0
4 weeks	1.2	1.2	1.0	1.2	1.8	1.4	1.0	1.4
5 weeks								
6 weeks	1.0	1.0	1.0	1.0	1.4	1.2	1.0	1.0
At 36/38° F								
Fresh (untreated)	2.0		2.7		2.0		2.3	
After shipment	2.0	1.0	2.4	1.6	2.2	1.2	2.2	1.8
Aging: 2 weeks								
4 weeks	1.6	1.0	1.2	1.0	2.0	1.6	1.6	1.6
5 weeks	1.2	1.0	1.2	1.2	1.8	1.2	1.8	1.2
6 weeks								
7 weeks	1.4	1.4	1.0	1.0	1.4	1.2	1.0	1.0
8 weeks								
9 weeks	1.0	1.0	1.0	1.0	1.4	1.4	1.0	1.0
At 28/32° F								
Fresh (untreated)	2.0		2.7		2.0		2.3	
After shipment	2.0	1.0	2.4	1.6	2.0	1.2	2.2	1.8
Aging: 2 weeks								
4 weeks								
5 weeks	1.8	1.0	1.0	1.0	2.0	1.8	1.8	1.6
6 weeks	1.6	1.0	1.0	1.2	1.6	1.4	1.8	1.8
7 weeks	1.4	1.0	1.2	1.0	2.0	1.0	1.4	1.0
8 weeks	1.0	1.0	1.0	1.0	1.6	1.4	1.0	1.2
9 weeks	1.4	1.0	1.0	1.0	1.8	1.4	1.0	1.0

[1] Each score represents the Average Flavor Rating with the
Scoring of 3.0 for Above Average
2.0 Average
1.0 Below Average.

TABLE 2

Bacteriological summary

Holding temp.	Age weeks	Belly No. 2		Belly No. 3		Belly No. 1		Belly No. 4	
		Heat seal	Heat seal irradiated	Heat seal antibiotic	Heat seal antibiotic irradiated	Vacuum pack	Vacuum pack irradiated	Vacuum pack antibiotic	Vacuum pack antibiotic irradiated
40/50° F	0[1]	20,000	800	300	0	40	0	1,000	0
	2	90,000	0[2]	700	20	1,000	0	1,100	0
	4	300,000	200,000	200,000	less 100	300,000	50,000	1,000	0
	6	3,000,000	600,000	100,000	1,000	12,000,000	10,000	6,000	less 1,000
36/38° F	0[1]	20,000	800	300	0	40	0	1,000	0
	4	900,000	2,000	300	10	40	1,000	300	20
	5	120,000	100	200,000	3,000	20,000	0	10,000	200
	7	10,000	1,000	33,000	300	180,000	200	8,000	500
	9	300,000	5,000	9,000	2,000	60,000	200	4,000	60
28/32° F	0[1]	20,000	800	300	0	40	0	1,000	0
	5	3,000	8,000	50,000	18,000	10,000	10	1,000	3,000
	6	2,000	40	30	0	5,000	170	1,000	0
	7	4,000	300	3,000	30	11,000	150	300	20
	8	100,000	30	2,000	30	1,000	0	3,000	0
	9	10,000	4,000	300	200	60,000	800	1,000	100

[1] After shipment.
[2] One mold.

scores were found in samples of bacon with very low bacterial counts indicating the importance of changes other than bacterial in causing flavor deterioration.

SUMMARY

Using bacterial changes and flavor ratings by a trained panel as criteria of product acceptability we established that holding temperatures, method of packaging, irradiation and addition of an antibiotic each had its effect on the quality of sliced bacon. Our results indicated that low storage temperatures (28–32° F) and vacuum packaging were slightly more effective in maintaining an acceptable product than any of the other treatments tested.

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The Effect of Sugar on the Flavor and Color of Smoked Hams[a, b, c]

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TRADITIONALLY, sugar has been employed in the curing of meat because of its reputed value in (a) enhancement or development of flavor, (b) development and protection of the cured meat color and (c) retardation of a putrefactive type of spoilage.

Although sugar is used in large quantities in meat curing, and its value in many products has been established, scientific research has not been able to clearly explain its role in ham curing. Grau *(4)* has suggested that flavor improvement and more uniform and rapid curing may not be due entirely to the sugar substances alone. Fields *(3)* has shown that other factors have a greater effect than does the presence of sugar on the chemical composition of cured products. Very little difference in quality of hams cured with different sugars was reported by Hoagland *(6)*. However, it has been pointed out by some workers *(2, 8)* that the development of certain flavors, other than those produced by salt, wood smoke, and oxidative changes in fatty tissue and a "mellowing" of the brashness of salt is the role of sugar in ham curing.

A more dramatic role for sugar has been proposed *(1, 4, 5, 8, 9, 10)* by a number of workers. These studies indicated that sugars aid in curing by maintaining acid and reducing conditions favorable to good color development and retention. The mechanisms by which this effect is brought about is not indicated by the workers but they suggest that it may be dependent upon the utilization of sugar by microorganisms or by the enzymatic systems of the meat tissues. There has been some contention that sugar indirectly helps to provide optimum pH for curing.

Also, it has been suggested that sugar and a certain number of reducing microorganisms are desirable in curing most meat products. However, any beneficial effects of sugar and microorganisms in developing the proper conditions for cured color can be offset by undesirable changes if the concentration of sugar and the type and number of microorganisms are not kept within desirable limits *(8)*.

These relationships between sugar and microorganisms would seem to be more applicable in "long term" curing methods than to the present commercial practices. The objective of this work was to study the effect of sugar on the color development and retention and flavor of hams cured three to seven days.

METHODS

Preliminary taste panels. Water and brine solutions comparable to the salt concentrations in hams were prepared with various concentrations of sucrose. The sucrose concentrations were 0, 0.5, 1.0, 1.5, 2.0, and 2.5% in water as well as in 1.4 and 1.8% NaCl solutions. These solutions were given to the taste panel in a random arrangement. The panel members were asked to rank the sample in order of increasing sucrose concentration.

In addition ground ham samples were used in a preliminary series of triangle taste tests. Two hams were pumped and cured in the manner in which the experimental hams were to be cured except that sucrose was omitted from the pickle. After processing, the entire lean portions of the hams were ground through a 3/16 in plate and thoroughly mixed. Four hundred to five hundred gram quantities were individually vacuum packaged in plastic bags (Cry-O-Vac) and stored at 35° F (2° C) until required but for not longer than 10 days. The ground ham was mixed with the appropriate concentration of sugar and served to the taste panel.

Preparation of whole hams for taste panel and color evaluation. In each experiment the appropriate number of pairs of hams were artery pumped to 108% of their green weight. Each pair represented a left and right ham from the same animal. The hams were randomized with respect to sides and cure in order to minimize the influence of animal variation. All of the pickles were the same except for the presence or absence of the sugar or other sweetening agent. A stock solution of a 60° salometer brine containing 1.75 lb $NaNO_2$ and 0.75 lb $NaNO_3$/100 gal was prepared. For a particular treatment the appropriate weight of sugar was added to a portion of this stock solution.

After pumping, the hams were placed in plastic bags (Cry-O-Vac) which were closed under vacuum. The hams were cured for 3 or 7 days at 40° F (4° C) and then processed to an internal temperature of 155° F (69° C) in an air conditioned smokehouse in accordance with the processing schedule listed in Table 1.

TABLE 1

Processing schedule for cured hams

Time	Smoke house temperature	Relative humidity	
(hrs)	*(° F)*	*(%)*	
4	140	80	Heavy smoke
12	160	80	No smoke
1	160	80	Heavy smoke

Initial (green ham) and final (smoked ham) pH determinations were made on samples from the same muscle at the butt end of each ham. The yields of the processed hams were calculated. One or two pairs of hams were sampled daily. Those hams not being sampled were held at 35° F (2° C).

The following analyses were performed on each ham.

(1) A portion of the center slice of each ham (*semimembranosus* and *biceps femoris* muscles) was used in taste panel tests to determine flavor differences. A panel of

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7 to 12 members was asked to distinguish between samples from each pair of hams in a triangle test and to state whether the distinction was made on the basis of flavor, texture, color or odor. The triangle tests were analyzed by the Chi Square method *(11)*.

(2) Specific areas of the hams were cut for objective and subjective color determinations. (a) Two adjacent center slices of each ham were cut for color analysis by reflectance spectrophotometry. One of these samples was wrapped in cellophane (du Pont LSAT) and exposed to 100 foot-candles of light at 35° F (2° C) for 5 hr. The other slice was wrapped in aluminum foil and held at 35° F (2° C). At the end of the exposure time reflectance measurements were made on the samples in a Beckman DU spectrophotometer with a reflectance attachment. The ratio of per cent reflectance at two wave lengths (60 mme and 57 mme) was used as a measure of the cured color. (b) A 10 g sample of ground ham from a center slice was weighed into one half of a Petri dish. The sample was spread out uniformly over the surface of the dish and exposed to 100 foot-candles of light for 2 hours at 350° F (2° C). At the end of this exposure period the sample was extracted with acetone and water in accordance with the procedure of Hornsey *(7)*. The extract was prepared in the dark to prevent fading of the solutions. A spectral analysis of the extract was made on a Beckman DK-2 recording spectrophotometer. Unexposed samples were cut from an adjacent area of each ham and analyzed in the same manner. (c) Sections of the muscle were cut and immediately wrapped in aluminum foil for subjective color analysis. This analysis was performed after all the hams had been sampled and necessitated holding some samples for a two week period at 35° F (2° C). When all the samples were available they were removed from the aluminum foil packages and wrapped in cellophane (du Pont LSAT) and their color ratings determined by a panel. The panel members rated the samples by placing them in order of preference based on the desirability of the cured color. The samples were rated again after exposure to 100 foot-candles of light for 5 hr at 35° F (2° C).

(3) Samples of ground ham from the butt end were analyzed for moisture and salt.

(4) After each ham was sampled according to the above procedures they were wrapped and stored at 35° F (2° C). When all of the hams had been sampled two additional sections (immediately lateral to the femur) of each ham were packaged in cellophane and in a vacuum package (Cry-O-Vac) and stored at 40–45° F (4–7° C) to observe the incidence of bacterial spoilage.

RESULTS AND DISCUSSION

The pH, yield and moisture, and salt concentrations were obtained to determine if all the hams were within the same relative range in these respects (Table 2). Except for a few hams where the yield was low or the salt concentrations were high, all the hams were considered normal. In those cases where there was a significant deviation from the average, the change in concentration or distribution of sugar or salt was considered when interpreting the data. In those instances where the salt concentration of a control ham was high, the taste panel did not comment as to the saltiness of the ham as compared to its experimental mate. The few low yields that occurred resulted from over-processing. However, all of the hams of the particular experimental treatment, as well as the appropriate control hams, were processed together in the same smokehouse and these deviations were thought not to introduce errors in the analysis of the taste panel data.

TABLE 2

pH, yield and moisture and salt concentration in smoked hams

Treatment	Initial pH	Final pH	Yield	Moisture	Salt
			(%)	(%)	(%)
38[1]—Sucrose	5.54	5.72	83.8	64.5	1.1
Control (No sugar)	5.59	5.80	83.9	64.5	1.1
43—Sucrose	5.54	5.77	87.1	65.0	1.4
Control	5.53	5.79	87.2	65.8	1.3
48—Sucrose	5.53	5.73	80.5	64.3	1.3
Control	5.62	5.77	85.1	64.1	1.3
50—Sucrose	5.51	5.89	94.2	67.3	1.4
Control	5.49	5.92	95.4	69.0	2.1
55—Sucrose	5.63	5.81	95.2	65.4	1.5
Control	5.63	5.84	95.5	65.5	1.5
60—Sucrose	5.73	5.89	96.3	67.4	1.1
Control	5.67	5.93	95.4	69.2	1.8
75—Sucrose	5.73	5.92	91.9	68.2	1.4
Control	5.96	6.20	95.6	70.3	1.5
75/30—Na cyclamate[2]	5.33	5.96	91.6	67.9	1.4
Control	5.96	6.20	95.6	70.3	1.5

[1] Pounds per 100 gal pickle.
[2] *SUCARYL*—Abbott Laboratories brand Na cyclamate.

The panel members were characterized as to their ability to distinguish between various increments of sugar in water and salt solutions. These preliminary experiments (Table 3) showed that most of the panel members (12 out of 15) could properly rank sucrose solutions of 0, 0.5, 1.0, 1.5, 2.0 and 2.5% in water. Only half of the panel members could rank a similar series when prepared in brine solutions equivalent to salt concentrations found in cured ham. This agrees with prior knowledge that sugar and salt combinations reduce the taste intensity of either component. No difference in ability to taste sweetness was found between 1.4 and 1.8% NaCl in the solutions used for tasting.

TABLE 3

Taste panel results of water and salt solutions containing sugar

Concentrationof sugar in series	Solvent	Number of judgments	Number correct
(%)			
0; 0.5; 1.0; 1.5; 2.0; 2.5	H_2O	15	12
0; 0.5; 1.0; 1.5; 2.0; 2.5	1.4% NaCl	15	7
0; 0.5; 1.0; 1.5; 2.0; 2.5	1.8% NaCl	14	7

The ability to taste small amounts of a material in water does not always predict taste acuity for the same material in a food product. The flavor tests, therefore, were continued to determine the various levels at which sucrose could be distinguished in ground ham.

Experiments were performed on ground ham samples (from hams cured without sugar) with the addition of known concentrations of sugar as a preliminary approach to the determination of threshold levels of sweetness. The significantly detectable level of added sucrose in ground ham was found to fall between 0.46% and 0.62% sucrose (Table 4).

Experiments then were extended to whole hams using the approximate thresholds which were found in

TABLE 4

Triangle taste panel results of ground ham samples mixed with sugar

Comparison	Number of judgments	Number correct
0.31% Sucrose vs. no sucrose	24	2
0.46% Sucrose vs. no sucrose	18	6
0.62% Sucrose vs. no sucrose	24	16***

***Significant at 0.1% level.

ground hams. These data and other preliminary experiments had indicated that the detectable level of sugar was approximately 0.5% (50 lb sucrose per 100 gal pickle).

As a general "rule-of-thumb" the final concentration within the ham was considered to be approximately one per cent of the pounds of sugar added to 100 gal of the pickle.

As the experiments progressed, it was found that the approximate threshold level of sugar which had been determined previously was not directly applicable when sugar was incorporated in the cure. Taste panel evaluations on slices from hams cured with the various concentrations of sweetening agents are summarized in Table 5.

TABLE 5

Taste panel results of triangle tests of hams cured with various sweetening agents when compared with unsweetened controls

Treatment pounds/100 gal pickle	Pairs of hams in experiment	Pairs of hams significant	No. of judgments	No. correct	Significant (based on total judgments)
25—Sucrose[1]	2	0	36	12	
50—Dextrose[1]	2	0	32	14	
38—Sucrose	4	1	68	28	
43—Sucrose	4	0	58	25	
48—Sucrose	4	0	63	19	
50—Sucrose[1]	3	2	52	29	***
50—Sucrose	4	1	51	24	*
55—Sucrose	4	1	86	40	**
60—Sucrose	4	2	73	37	**
75—Sucrose	4	3	70	44	***
75/30—Na cyclamate[2]	4	2	77	43	***

[1] Cured for 7 days.
[2] *SUCARYL*—Abbott Laboratories brand Na cyclamate.
* Significant at 5.0% level.
** Significant at 1.0% level.
*** Significant at 0.1% level.

The threshold level for sucrose appears to be close to 75 lb per 100 gal of pickle (108% pump). Factors such as ham variation, pickle composition, pumping procedure, evenness of pickle distribution through the hams and curing time may have an effect upon the intensity of flavor in the final product and, therefore, influence the level at which flavor differences are discerned. The effect of another sugar (dextrose) and an artificial sweetener (Na cyclamate [4]) also was studied. Although complete data on these two compounds were not obtained, it appears that approximately twice as much dextrose and $\frac{1}{30}$ as much cyclamate are required to give a taste response equivalent to sucrose. This would conform to the approximation that dextrose is half as sweet as sucrose and cyclamate is 30 times as sweet as sucrose.

[4] *SUCARYL*—Supplied by Abbott Laboratories, North Chicago, Ill.

In several instances when the judgments for the 4 ham pairs were pooled the differences betwen treatments were considered significant, but when taken singly only one pair of hams differed in flavor. This situation may be the result of either:

(1) The greater differences needed for statistical significance with fewer judgments.

(2) Differences in physical distribution of sweetener through the ham.

(3) The actual difference between ham pairs.

As illustrated in Table 5, as the level of sucrose increased, more pairs of hams were properly identified, more correct judgments were obtained and the level of significance increased accordingly, thus indicating an effect due to the increased sugar concentration. At a sugar concentration of 75 lb of sucrose per 100 gal of pickle, 3 out of 4 pairs of hams differed significantly in flavor and the difference between individual judgments was significant at the 0.1% level (Table 5).

During the course of the taste panel, the judges were asked to rate the samples for acceptability and to comment on flavor characteristics (sweet, salty, sour, bitter, etc.). A compilation of the taste panel data was made and the comments are summarized below.

(1) Differences in desirability were not consistent with treatments and could not be attributed to the sweetening agent.

(2) Comments made by judges correctly identifying the triangle did not differ from those of the entire panel, indicating that while a flavor difference existed a flavor preference did not.

(3) There was no association of any off flavor or odor (rancid, bitter, sour, flat) attributable to any treatment.

Of the methods used in the color analysis of the ham samples, the extraction method was used more extensively. Reflectance methods have found best application in meat products where the surface to be measured is extremely uniform as found in comminuted meat products. The surface of a ham slice is non-uniform due to the presence of connective tissue and fat resulting in possible errors in the reflectance readings. In the few experiments in which this method was employed, results obtained indicated random variation with no effect upon color due to the sweetening agents.

Since the subjective color evaluation does not yield good analytical data, the formal panel was disbanded early in the experiments and visual observations were made during the preparation of the hams for other analyses. In all cases, both with formal panel evaluation and informal comments by research workers, subjective evaluation confirmed results obtained with objective measurements of reflectance and spectral analysis.

A sample of each ham prepared in the studies was analyzed for total pigment and nitroso-heme pigment by the extraction methods outlined by Hornsey. The

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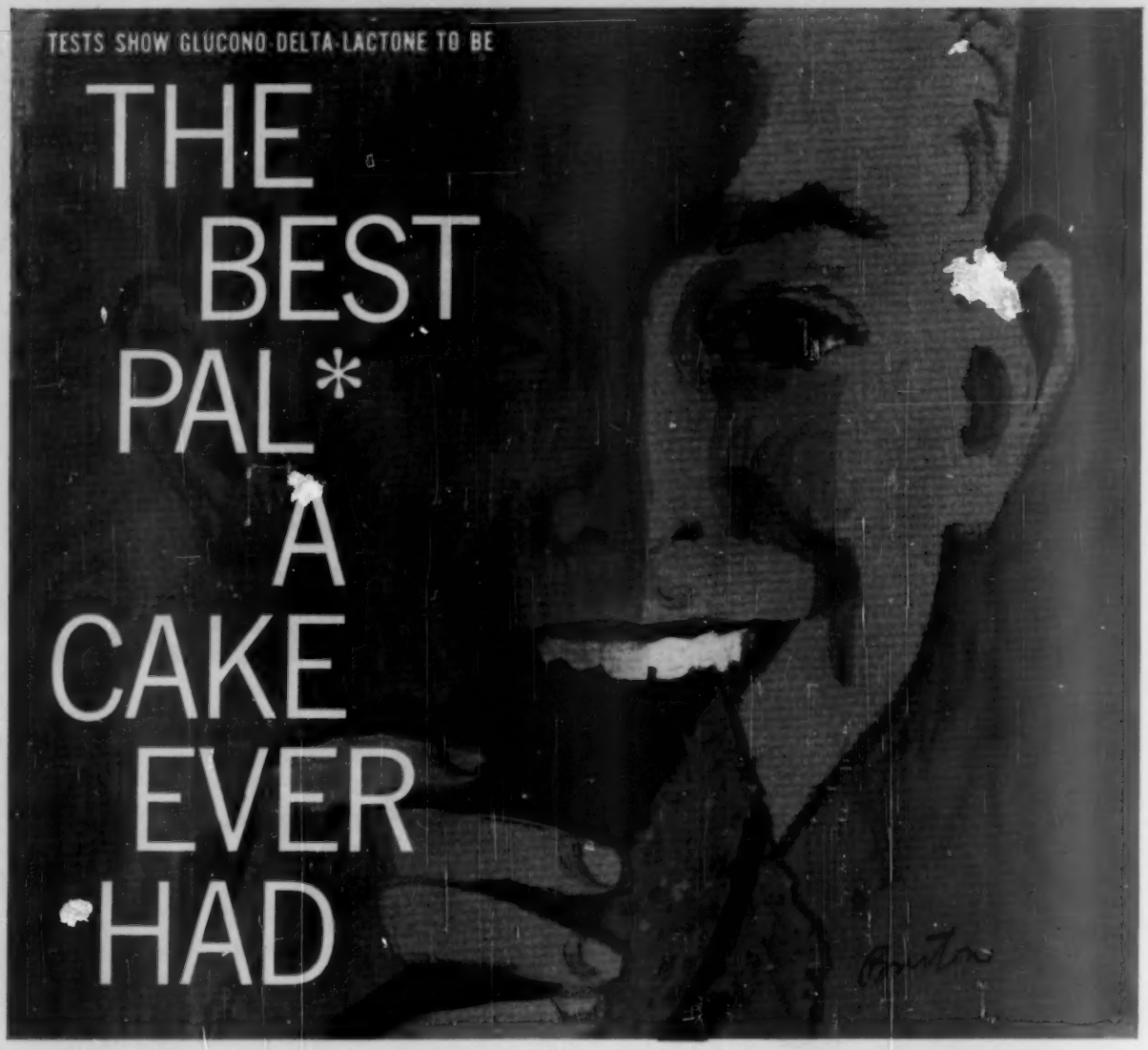

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average concentrations of total pigment and nitroso-heme pigment are tabulated in Table 6.

The concentrations of total pigment illustrate the variation in pigment among the animals. In order to subject the data to a more precise analysis, the concentration of the nitroso-heme was calculated as the per cent of the total pigment. In this way, it was possible to observe the effect of treatments upon the conversion to the nitroso-heme pigment and the light stability of the color.

A statistical analysis indicated no effect of treatments upon the percentage of pigment converted during the curing process. Likewise, the degree of fading of the nitroso-pigment during light exposure was unaffected by treatments. As would be expected, light exposure significantly reduced the percentage of cured meat pigment (Table 7).

Under these experimental conditions, the per cent of heme pigment converted to nitroso-heme compounds appears to be relatively constant at 65%.

TABLE 6

Pigment content of hams cured with various sweetening agents

Treatment	No. of hams	Total pigment	Nitroso-heme pigment	
			Fresh	Light faded[1]
		(ppm)	(%)	(%)
7 day cure				
No sweetener	4	105	73	47
25[2]—Sucrose	4	104	81	53
No sweetener	4	105	73	47
50—Dextrose	4	120	77	55
3 day cure				
No sweetener	4	125	56	49
38—Sucrose	4	123	61	48
No sweetener	3	121	53	43
43—Sucrose	3	111	54	39
No sweetener	4	126	61	45
48—Sucrose	4	140	64	46
No sweetener	4	113	59	46
55—Sucrose	4	114	55	44
No sweetener	3	99	66	46
60—Sucrose	3	97	60	50
No sweetener	4	126	54	46
75—Sucrose	3	100	51	43
No sweetener	4	115	54	46
75/30 NA cyclamate[3]	3	113	56	42

[1] Light faded—2 hours at 100 foot-candles of light at 35° F (2° C).
[2] Pounds per 100 gal of pickle.
[3] *SUCARYL*—Abbott Laboratories brand Na cyclamate.

TABLE 7

Analysis of variance of the per cent concentration of nitroso-heme in extracts of hams cured with various sweetening agents

Source of variation	Degrees of freedom	Mean square
Treatments	6	77.19
Color (light exposure)	1	3259.00***
Interaction	6	21.46
Residual	71	40.62

*** Significant at 0.01%.

This was considerably lower than the per cent conversion obtained when the hams were cured for 7 days prior to processing (70–80%) indicating a curing time effect on color production.

Examination of samples wrapped in cellophane and vacuum packages and stored at 40–45°F (4–7° C) for 10 days revealed no putrefactive odor in any of the packages. Total plate counts on selected packages of both types revealed large numbers of bacteria which were primarily of the *Lactobacillus* genus. No differences attributable to treatment were observed.

SUMMARY

Between 0.50–0.75% sugar appears to be required to reach the threshold level for detection of sweetness in hams. This would correspond to 50–75 lb sugar per 100 gal of pump pickle. This is believed to be higher than the concentration of sugar usually employed in commercial practice.

Color analysis indicates no effect of sugar upon color production or stability. An effect upon the amount of color development due to length of cure was observed. This would indicate that the effects of sucrose upon color development and retention noted by other workers on long cure hams are not of significance when curing is limited to a few days.

Bacterial flora did not appear to be affected by the treatment. If a sweetening agent is desired in rapidly cured hams, sucrose, dextrose, or a cyclamate appear to be interchangeable.

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Efficacy of Oxytetracycline for Aging Beef[a, b]

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STUDIES PREVIOUSLY REPORTED by Sleeth *et al. (10, 11)* have indicated the desirability of aging beef at elevated temperatures for a short duration. Organoleptic characteristics of the high temperature aged product were comparable to that aged in the conventional manner. However, in some instances, beef aged more than one day at temperatures higher than 80° F had a tendency to develop microbial growth on the surface along with some deep seated spoilage. Recently, various antibiotics, such as oxytetracycline (OTC), have been suggested as a means of controlling spoilage of beef during aging at high temperatures.

According to Ayers *(1)*, measures to minimize bacterial invasion and growth on and in animal tissue must begin prior to slaughtering the animal and care must be exercised in handling the carcass throughout the dressing operation.

Jensen and Hess *(4)*, in a review of the literature of ante-mortem and post-mortem inspection of animals, reported much evidence was available to support the theory that bacteria are present in tissues of healthy animals. It was further indicated that bacterial invasion of ham tissues occurs during the dying period or post-mortem. However, Lepovetsky *et al. (5)* examined commercially slaughtered beef and found most of the bacteria within the meat in the lymph nodes and relatively few bacteria in the bone marrow and skeletal muscle. Thus, it is apparent that these organisms must be controlled in the aging of beef. Consequently, the development of satisfactory methods to prevent spoilage of beef during high temperature aging is a serious problem.

Goldberg, Weiser, and co-workers *(2, 13, 14)* studied the use of antibiotics in the preservation of fresh beef and found that OTC successfully prolonged the keeping quality *(2)*. These studies were conducted with ground beef *(2)* and post-mortem infusion of beef rounds and whole animals *(14)*. However, the infusion technique was difficult and time consuming.

From this work, it seemed to Sacchi *et al. (7)* that a more complete distribution of the antibiotic to all tissues could be obtained by utilizing the vascular and lymphatic systems of the animal. In this way, the antibiotic would be carried by the blood and lymph to the most remote portions of the body and be distributed through all the soft tissues. An ante-mortem intraperitoneal injection appeared to be the most convenient method for the introduction of the antibiotic. This method offered some possibilities and was found to be quite practical under their experimental conditions.

This investigation is concerned with the effect of ante-mortem injection of an aqueous antibiotic (OTC) solution to control surface and internal microbial growth during aging.

EXPERIMENTAL MATERIALS AND METHODS

Twenty-seven Utility cattle, weighing 600–700 lb, were used in this study. Low grade cattle were utilized since all product receiving antibiotic had to be destroyed. All cattle, except those serving as controls, were injected either intraperitoneally or intramuscularly (anterior portion of the tail) with 0.60 or 0.80 mg OTC per lb of body weight 30 min to 6 hr ante-mortem. The antibiotic was dissolved in 15 ml of distilled water. Five ml aliquots were injected at 3 sites circumventing the tail, 4–5 in posterior to the tail head.

Experiment 1. This test involved 15 of the above cattle. Beef animals were slaughtered and dressed in the usually accepted manner. Immediately after slaughter, the carcasses were thoroughly washed with tap water. The carcasses were sampled bacteriologically in 3 areas: namely, external portion of the neck, between the 9th and 10th rib adjacent to the thoracic vertebrate, and inside of the round posterior to the pelvic arch using the Millipore Filter technique *(8)*. The determinations consisted of total count, coliform, yeast and mold. Carcasses were sampled every 24 hr during the 48 hr aging period.

The right side of each carcass was placed directly into the aging room without chilling. These were held under ultraviolet radiation 48 hr at 86° F and 90% relative humidity. The intensity of the germicidal ultraviolet energy was 150–175 microwatts per square centimeter at the surface of the product. At the completion of this period, the quarters were chilled 24 hr and processed. The left side of each carcass was held 15 days at 36° F and relative humidity of 90%.

Blood samples were taken ante-mortem at 0, 30 min, and every hour after the antibiotic injection until slaughter. Heparin was used as the anticoagulant. The freshly drawn blood was immediately centrifuged. The plasma portion was drawn off and frozen for antibiotic assay. At the time of slaughter, samples of blood, heart, liver, kidney, spleen and muscle were taken from each animal for bioassay. Muscle samples were removed for assay from the short loin every 24 hr during the aging period for the first 72 hr for both high and low temperature treatments and also at the end of 15 days from the low temperature treatment. Synovial fluid was taken from the stifle joint at 0, 24, 48 and 72 hr aging for bacteriological determinations. The popliteal lymph node was excised from the round and a portion of the *semimembranosus* was taken at the end of each aging period for total bacteriological counts.

Experiment 2. Twelve cattle were used in this study. All aging conditions and procedures were the same as in Experiment 1, with the following exceptions. The right side of 6 carcasses was sprayed externally with 10 or 20 ppm solution of OTC. The remaining 6 carcasses were sprayed with a combination of 20 ppm of OTC and 20 ppm of nystatin. The entire surface was thoroughly moistened. No ultraviolet radiation was used. Spraying was accomplished by means of a pump with an ordinary paint spray attachment.

Oxytetracycline assay procedure. The method of Grove and Randall *(3)* was utilized with the following modifications. A 10 g muscle or organ sample was ground one minute in a micro Waring blender with 10 ml of monobasic phosphate buffer,

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[a] Presented before the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 18, 1959.

[b] Journal Series Paper No. 2002, approved by the Director of the Missouri Agricultural Experiment Station.

[c] Present address: Meat Research Section, Food Research Division, Armour and Company, Chicago, Illinois.

pH 4.5. The resulting slurry was centrifuged 10 min. The supernatant was used to fill 3 cylinders in each of 3 plates for each unknown sample. The cylinder-plate method was used with *Bacillus cereus var. mycoides* as the test organism. Readings were made after 18 hr incubation at 30° C.

Round steaks one inch thick and rib steaks three-fourths inch thick were broiled to internal temperatures of 140° F (medium rare) and 160° F (medium well done). These were frozen and ground 3 times before assay. The same assay procedure was followed as above except 15 ml of buffer was used in order to obtain sufficient supernatant for the platings.

Ten ml of blood plasma were buffered with 10 ml of a diluent containing one part of 3.5% bovine albumin plus 2 parts of phosphate buffer, pH 4.5. This solution was plated in the same manner as described above.

Bacteriological procedure. The Millipore Filter technique of Silliker *et al. (8)* was used. After the sample was prepared, the material was plated according to conventional procedures. Nutrient agar was used for total count, desoxycholate agar for coliforms, and Littman Medium for yeast and mold. Total count and coliform samples were incubated 48 hr at 37° C while yeast and mold samples were incubated 72 hr at 30° C.

RESULTS AND DISCUSSION

Intraperitoneal injection of OTC was not satisfactory. Considerable difficulty was encountered in puncturing the rather elastic intraperitoneal lining and as a result, the antibiotic was discharged frequently in the flank. The antibiotic consistently caused a marked yellowing and a distinct necrotic condition in the flank area which had to be removed after slaughter. This detracted from the appearance of the carcass and would decrease the market value.

Intramuscular antibiotic injections in the tail were found to be rapid, easy to administer and more satisfactory than intraperitoneal injection. Although there was some necrosis and yellowing at the site of injection it was in an area of low market value and would not detract from the appearance of the carcass.

In the first phase of this study, 0.60 mg OTC per pound of body weight were injected to control deep seated spoilage when the product was aged at 86° F. Ultraviolet radiation was used to control surface growth. After 24-hr aging, the controls were completely putrid. Carcasses which had received OTC injections were sound internally but objectionable surface greening and odoriferous characteristics were apparent in the neck, rib, and shank regions at the end of the 48-hr aging period.

The antibiotic treatment was increased to 0.80 mg OTC per pound of body weight. Carcasses were aged under the same conditions as described above. Adequate product protection was obtained during the 48-hr aging and subsequent chilling period of 24 hr. There was no evidence of internal spoilage or external sliming.

The ultraviolet radiation caused a slight yellowing and "burned" appearance on the surface of the product under the environmental conditions utilized. To eliminate this condition, a surface spray of 10 ppm OTC was applied previous to placing carcasses into the aging room and ultraviolet radiation was discontinued. Even though the surface bacteriological counts were less than the controls (Table 1), this treatment was not satisfactory since by inhibiting only bacteria, yeast and mold development flourished.

TABLE 1

The effect of a post-mortem surface spray on total bacteria count of beef at various intervals during the aging period[1]

Surface spray post-mortem	n	Surface location	Bacteria total count × 10^6 per 2.5 sq in		
			At slaughter	24 hr	48 hr
Control	2	Round	.....	183.0	710.0
		Neck	.....	214.0	710.0
10 ppm OTC	2	Round	.....	38.9	303.5
		Neck	.....	1.4	5.4
20 ppm OTC	2	Round	.002	30.0[2]	155.5
		Neck	.005	1.8	19.8
		Rib	.000	.2	2.5
20 ppm OTC	2	Round	.00004	3.0[2]	7.7
20 ppm Nystatin		Neck	.00002	3.0[2]	24.7
		Rib	.00000	.002	1.0

[1] Environmental aging conditions were 86° F and relative humidity 90%.
[2] Estimated.

Carcasses were entirely normal internally but an excessive amount of yeast and mold growth occurred over the carcass by the end of 24 hr aging. These caused greening and putrification on the tail head, kidney knob, fore shank, plate and neck after 48 hr aging.

A reduction in surface total counts was accomplished when the carcasses were sprayed with 20 ppm OTC (Table 1). However, the same yeast and mold conditions existed as described above.

An antifungal antibiotic, nystatin, was utilized to control the fungi on the surface. A combination spray, consisting of 20 ppm OTC and 20 ppm nystatin was applied prior to aging. The results of this treatment are also in Table 1. There was a significant decrease in surface total counts over previous treatments. Yeast and mold growth was reduced. All treated carcasses were sound internally and externally at the conclusion of the 48 hr aging and 24 hr chilling period.

Total coliform population on all product aged at elevated temperature followed the same pattern as the bacteriological counts. Synovial fluid counts increased slightly during the aging period. The elevated temperature also produced higher counts than control carcasses aged at 36° F but were not significant. Samples of the popliteal lymph node and *semimembranosus* taken at the end of the respective aging periods resulted in a higher total bacteriological count from the beef aged at 86° F as compared to 36° F. This difference was not significant.

The residual quantities of OTC detected in various tissues of beef injected ante-mortem with 0.80 mg per pound of OTC are given in Figure 1. The levels of OTC varied greatly from one tissue to another. This has been demonstrated also by McMahan *et al. (6)* in beef tissues, Silvestrini *et al. (9)* and Ayers *(12)* in poultry tissues.

Bioassays revealed that the level of OTC in blood plasma increased very sharply during the first hour after injection. The OTC concentration decreased between the first and second hour and then leveled off until the fifth hour. At this time a gradual decrease was noted.

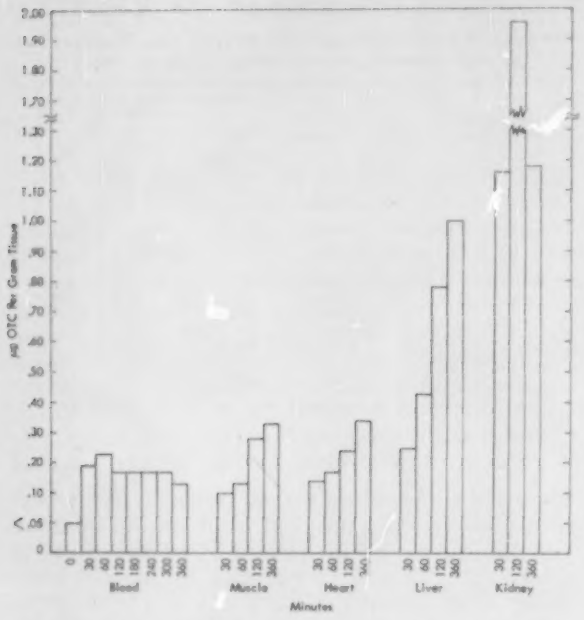

Figure 1. The effect of time of ante-mortem injection on OTC residue in various beef tissues. OTC injected at rate of 0.80 mg/lb body weight.

Samples of muscle, heart and liver, taken at the time of slaughter from animals injected ante-mortem at the time intervals indicated in Figure 1, reveal a sharp increase for the first 2 hours and then gradually increasing to 6 hours without reaching a plateau. This would indicate that OTC residual was accumulating in these tissues more rapidly than it was being metabolized and dissipated. A very rapid movement of OTC from the site of injection to the kidney was demonstrated. It will be noted that the level of OTC decreases very rapidly two hours post-injection.

Even though the sensitivity of the assay procedure for this study was .03 mcg/g, no detectable residual was found in spleen. Explanation for this phenomenon is not known at this time.

Assay of muscle samples from the short loin every 24 hours during the high temperature aging period indicated a small, but not significant, decrease in OTC residual. Thus, the effect of aging at 86° F did not have any appreciable effect on OTC activity. This is important from the standpoint of providing adequate product protection throughout the aging period.

The effect of cooking on OTC residues is given in Figure 2. Adjacent rib steaks from OTC injected cattle were broiled to internal temperatures of 140° F (rare) and 160° F (medium well done) and these compared to raw samples. Results indicated that 18% of the antibiotic was destroyed in steaks broiled to the rare state. No detectable residue (<.03 mcg/g) was found in the medium well done steaks. This would indicate that if beef treated with OTC was cooked to 160° F before consumption, untoward effects of the antibiotic to the public health would be minimized.

SUMMARY AND CONCLUSION

The tail, as a site of ante-mortem antibiotic injection, offers greater possibilities than any other injection site previously utilized.

Adequate product protection from external sliming and internal spoilage was provided beef that received an ante-mortem intramuscular injection of 0.80 mg/lb of OTC which was aged under elevated temperatures and ultraviolet radiation or an external combination spray consisting of 20 ppm OTC and 20 ppm nystatin. However, an undesirable appearance developed on the surface of the product due to ultraviolet radiation. By utilizing the external spray, the normal appearance of the product surface was maintained during the aging process.

Total surface bacteria, coliform, yeast, and mold counts were negligible after the carcasses were washed and sprayed with OTC and nystatin prior to aging. Counts increased during the aging period until processed but were not extensive enough to cause sliming and spoilage. Total bacteriological counts of the synovial fluid, excised popliteal lymph node and the *semimembranosus* increased slightly during aging but were not significant.

The concentration of OTC in various beef tissues was affected by the time lapse between injection and slaughter. The OTC concentration in the blood decreased with time, while the concentration in other tissues, except kidney and spleen, increased and had not plateaued at the end of six hours. Residual antibiotic in the kidney decreased after two hours while no OTC was found in the spleen.

Under conditions of this study, product protection did not appear to be a function of time the OTC was injected ante-mortem. It is significant to note the adequate protection received when animals were injected only 30 minutes prior to slaughter.

Aging temperature did not influence the dissipation rate of the antibiotic in the muscle tissue.

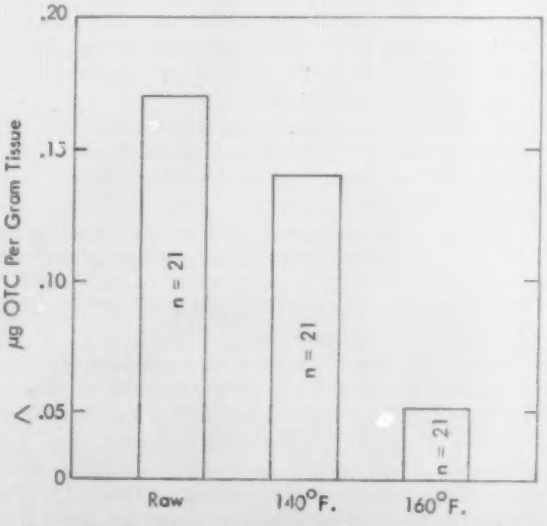

Figure 2. The effect of cooking on OTC residues in beef.

There was a substantial reduction in OTC concentration of medium rare steaks with no detectable residual found in the medium well done steaks.

Acknowledgments

The authors wish to express their gratitude to Chas. Pfizer and Co., Inc. for a grant-in-aid and oxytetracycline (Biostat). To E. R. Squibb and Sons, we are indebted for furnishing the nystatin (Mycostatin). We are also very grateful to Dr. H. S. Goldberg, Medical Microbiology Department, University of Missouri, for his technical advice and assistance.

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Use of Emulsifiers and Emulsified Oils to Reduce Cohesion in Canned White Rice[a]

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SHORT-GRAIN OR PEARL RICES produced principally in the western states, normally are quite sticky as well as cohesive when cooked. The sticky character was largely overcome by a canning process developed at this laboratory *(4, 5)*. A subsequent market test of this product, however, revealed that an undesirable degree of cohesiveness remained, making the rice difficult to remove from the container and to separate into individual kernels *(2)*. This report is concerned with treatment of the rice with surface-active materials[c] and vegetable-oil emulsions to reduce cohesion between kernels without affecting other properties of canned rice which make it superior to freshly cooked rice.

MATERIALS AND METHODS

The rice used was commercially milled U S No 1 Fancy California pearl. Oils for the emulsions were commercially refined vegetable oils, and most of the surfactants were research samples obtained directly from manufacturers.

Rice was canned by the procedure described below. Tap water, acidified to pH 5.0 to 5.5 with 2 drops of glacial acetic acid per liter, was used for soaking and cooking the rice. Controls had the same treatment except that the final rinse was omitted.

Milled rice, 1250 g, was soaked 30 min in 1000 ml of water. It was then transferred to a stainless-steel wire basket and rinsed in cold running tap water to remove dirt, loose starch, and rice polish. The basket of rice was next immersed in 3500 ml of boiling water. Temperature dropped quickly to 185°F (85° C), where it was held for 5 min. This cooking time raised the moisture content of the rice to 51 ± 1%.

The product was thoroughly rinsed in cold running water, drained, rinsed in 3500 ml of emulsion or emulsifier for 1.5 min, drained again, and packed into 303 x 406 C-enameled cans (336 ± 0.5 g per can).

The cans were sealed under 28 in of vacuum and retorted 60 min at 240° F (116° C). After the steam pressure was released, the cans were cooled in water.

Oil emulsions were usually prepared by adding one part of emulsifier to 10 parts of vegetable oil, and after the mixture was heated to 149 to 158° F (65 to 70° C) water of the same temperature was slowly stirred in until the oil concentration of the dispersion was 50% or 25%. The dispersions were passed 3 times through a hand homogenizer (manufactured by Club Aluminum Products Co.)[d] to obtain emulsions which were diluted with water to the desired strength just before use. Except where otherwise stated in the text, 5% cottonseed oil emulsions prepared with 0.5% polyoxyethylene sorbitan monooleate (Tween 80) were used in all treatments. (Tween 80 was completely ineffective when used alone.)

Surfactant-water dispersions were prepared in the same general manner as the oil emulsions. When necessary, small amounts of alcohol (2.5 to 5.0%) were added to aid dispersion; traces of sodium stearate (0.01 to 0.05%) were sometimes used to prevent gelation of the emulsions. If the emulsifier was water-soluble, the homogenization step was omitted. All blends were made with 10% concentrations of emulsifier and diluted with water as needed just before use.

Organoleptic comparisons were made by the duo-trio procedure described by Peryam and Swartz *(3)* or by a ranking method described by Boggs and Hanson *(1)*. The rice was prepared for serving by adding ½ cup warm water to the contents of a No. 303 can in a saucepan and cooking 2 to 3 min at low heat, stirring 2 or 3 times until the water is adsorbed and rice is heated through (salt normally added at this point was omitted for the taste panel tests).

The effect of treatment on cohesiveness was assayed as follows: Canned rice was aged 7 days at ambient temperature. Then both can ends were removed and the contents transferred intact to a special shaker container. This container is 4 in wide, 6 long, and 4½ deep and has a perforated false bottom with staggered 3/16-in perforations on ¼-in centers. It has a tight-fitting lid and a bottom receiver pan 2½ in deep. This assembly was shaken for 1 or 2 min on a reciprocating shaker having a 1-in stroke and a speed of 330 cycles per minute. The percentage by weight of single kernels passing through the screen was used as a measure of the reduction in cohesion and is referred to as the *separation index*.

Because of the low precision of this method (±10%), all results reported are averages of at least duplicate and in most cases triplicate determinations.

RESULTS

Physical variables affecting separation index. As would be expected, duration of shaking affected the amount of kernel separation. This is illustrated in Figure 1. Relative values for one and two min of shaking, however, were reasonably constant over the full range of numerical values obtained for a series of different samples. Two minutes of shaking were chosen as standard for all but the oil-concentration series, because it generally yielded a slightly wider spread of values and hence made possible a more accurate interpretation of results. One minute of shaking was used for the oil-concentration series since 2 min of shaking passed most of the rice through the screen and thus would bunch the values in the higher portion of the curve (Figure 3).

The weight of rice placed in the can had a significant effect on the separation index, as shown in Figure 2.

For testing purposes a slight overfill of 336 g per can was chosen as the standard weight in an effort to minimize any erratic packing effects that might be caused by non-uniform subsequent handling of the cans of rice. Actually, better separation of grains is obtained with a lighter fill, such as 326 g per can.

An increase of 1% in moisture content of the rice within the recommended range of 50 to 55% caused about a 2% decrease in the separation index. Such processing variables as amount of rinsing following cooking and rate of cooling of cans following retorting showed no measurable effect. Because the temperature at which the canned rice is held after

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[a] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pa., May 18, 1959.

[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

[c] Individual manufacturers should consult the Food and Drug Administration, Washington 25, D. C., and the food and drug officials of the individual states involved, to determine if the use of any proposed additive is permissible, and if so, what limitations are placed on its use.

[d] Mention of specific products does not constitute endorsement by the U. S. Department of Agriculture over others of a similar nature not mentioned.

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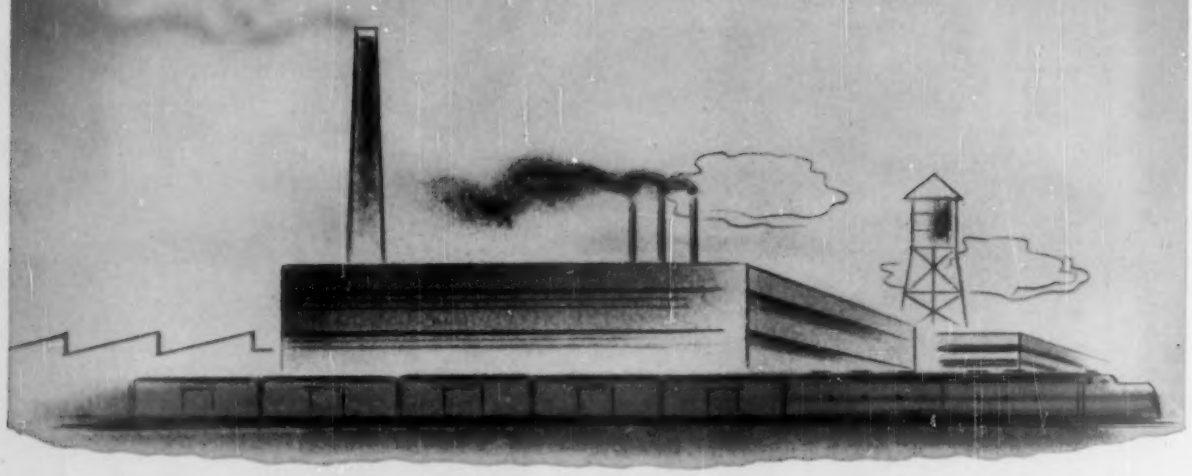

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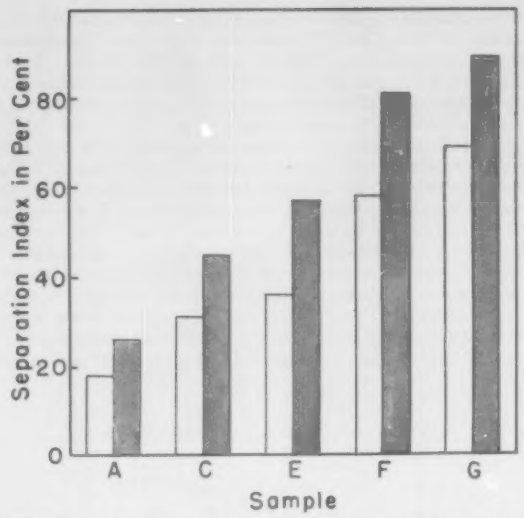

Figure 1. Comparison of shaking times in determination of separation index for a series of samples selected to provide a wide range of values. Blank bars signify one minute of shaking and shaded bars signify two minutes.

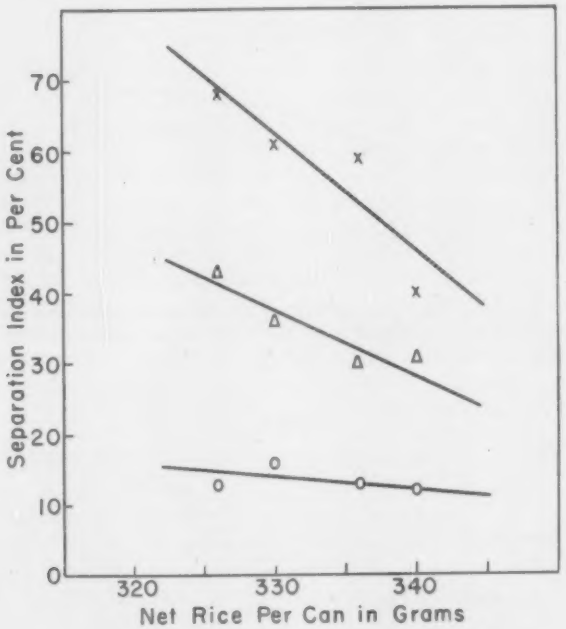

Figure 2. The effect of net weight of rice per can on separation index. The circles represent untreated rice, the triangles represent emulsifier (Span 80) treated rice, and the crosses represent emulsion treated rice.

processing affects its cohesiveness, comparisons of treatments made on different days may be of questionable validity; a control sample was therefore usually included in each series of tests. The effect of temperature is discussed more completely in a later section.

Effect of processing treatments on separation index. Prior to evaluation of particular emulsions and emulsifiers as cohesion inhibitors, tests were conducted to determine the stage or steps of processing where the treatment would be most effective. The results are shown in Table 1.

The greatest improvement was achieved by application of emulsions at both the cook and rinse stages, or at all three of the processing stages (soak, cook, rinse). Although the pattern of improvement was slightly different depending upon the emulsifier tested, treatment only at the rinse stage was nearly as effective in all cases as any combination of treatments investigated. Because of its simplicity and practical economy, this treatment was used for the remainder of the work reported in this paper.

Because the surface-active materials used to form the emulsions can exert an important effect on cohesiveness of the canned rice when used by themselves, a large number of different types and products from different sources were tested. Table 2 lists the most effective of 42 products which were screened.

Although it was recognized that combinations of specific emulsifiers might show synergism in reducing cohesion, no investigation of this possibility was made.

Tests conducted with a series of seven 5% oil emulsions, each prepared with a different emulsifier, showed no significant differences in effectiveness, even though the emulsifiers varied widely in effectiveness when used by themselves. Moreover, no difference in effectiveness was found when the concentration of emulsifiers in 5% oil emulsions varied from 0.1 to 2.0%.

The concentration of oil in the emulsion used to rinse rice before canning was an important variable, as shown in Figure 3.

The separation index was directly related to the logarithm of the concentration of oil in the emulsion. A similar relationship was found for concentration of emulsifiers, when used alone, although the rate of change differed for each of three emulsifier types tested. The amount of oil retained by the rice in these experiments ranged from 0.27 to 1.01% (untreated control contained 0.11%) and was related linearly to the concentration of oil in the emulsions used.

The kind of oil used in the emulsions had only a minor effect on separation index. Cottonseed, rice-bran, corn, safflower, and peanut oil gave essentially equal results. Sesame oil gave a slightly better separation and soya oil, slightly poorer results. That variations in the duration of rinsing had no significant effect was shown with three series of samples rinsed one, three, and five minutes using an oil emulsion and two different emulsifiers.

TABLE 1

Comparison of the effectiveness of oil emulsion and emulsifier treatments when applied at each of the processing steps singly and in all possible combinations

Stage where treatment is applied	Separation index, %	
	5% oil emulsion	0.5% emulsifier[1]
(Untreated)	26	13
Soak	28	14
Cook	45	37
Rinse	84	32
Soak and cook	57	38
Soak and rinse	81	26
Cook and rinse	89	31
Soak, cook, and rinse	89	38

[1] Sorbitan mono-oleate (Span 80).

TABLE 2

The effect of rinsing with certain emulsifiers on reduction of cohesiveness in canned rice[1]

Emulsifier used	Separation index
	(%)
(Untreated)	17
Mono-, di-, and triglyceride mixture (Duex)	79
Sorbitan mono-oleate (Span 80)	59
Glyceryl mono-oleate	58
Mono- and diglyceride mixture (Atmul 82)	52
Mono- and diglyceride mixture (Atmul 84)	48
Hydroxylated lecithin (Centrolene S)	42
Lecithin (Gliddol n.s.)	35
Propylene glycol monococat[illegible]	37

[1] Applied at 1% level to enhance effect. Water rinse between cooking and emulsifier treatment was omitted, so that treatment temperature was above normal.

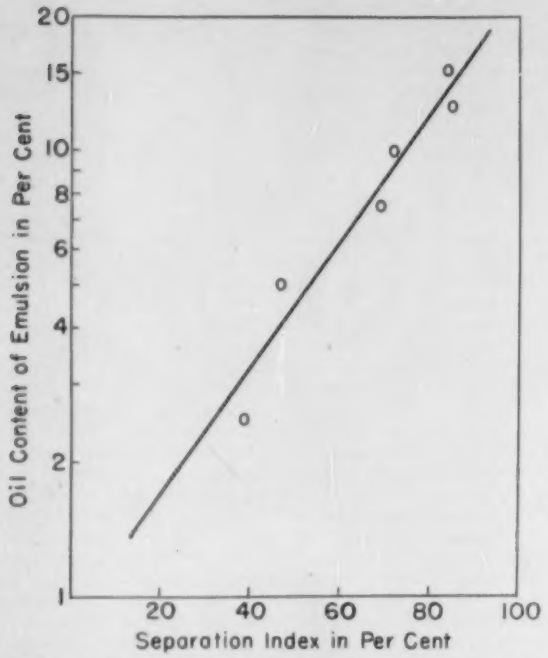

Figure 3. The relationship of separation index (one minute of shaking) to concentration of oil in emulsions used to rinse cooked rice before canning.

TABLE 3

Effect of treatment temperature on separation index of canned rice

Sample treatment	Separation index, %	
	68° F	131° F[1]
(Untreated)	19	20
5% oil emulsion	77	83
Hydroxylated lecithin (Centrolene 8)	19	29
Mono-, di-, and triglyceride mixture (Duex)	18	60
Mono- and diglyceride mixture (Atmul 80)	23	53
Glyceryl monostearate	17	23
Sorbitan mono-oleate (Span 80)	47	67

[1] Samples treated at 131° F were first rinsed with water at this temperature.

The temperature at which the rinse treatment is applied to the rice was found to be important. Typical results are shown in Table 3. Although the increases in the separation index at the higher temperature are small in several instances, they are quite substantial in others. In commercial practice, a hot rinse just before can filling would help to obtain the relatively high vacuum (26 inches minimum) required for stability of the canned rice *(4, 5)*.

Effects of time and temperature on separation index. Although a holding period of one week at room temperature between canning and testing of experimental lots of rice had been selected for convenience, changes in the separation characteristics seem to continue at a mensurable rate for several weeks. Figure 4 summarizes results obtained for an emulsion-treated and an untreated lot of rice aged at room temperature for periods up to 29 days. The improvement in separability occurred relatively rapidly during the first week or two but had virtually ceased after four weeks.

Further clarification of this time-temperature effect was obtained after aging freshly canned treated and untreated rice one week at four temperatures ranging from 34° to 90° F (1° C to 32° C). Rice temperatures were at or near holding temperatures when tested. Results are shown in Table 4. The lower temperatures not only markedly accelerated the changes, but brought about higher separation values than had been obtained in four weeks of conditioning at room temperature. The last two columns of Table 4 indicate that, at most, only a small portion of the observed differences in separability of samples aged at different temperatures could be attributed to rice temperature at time of testing.

Organoleptic evaluations. It is conceivable that after the emulsion treatment, the small amount of oil retained by the rice could produce organoleptic effects. This possibility was examined by paired difference (duo-trio) testing of rice treated with emulsions containing 2.5, 5.0, and 7.5% of oil, as compared to untreated samples. The results are summarized in Table 5. The rice treated with emulsions containing 5%, or more, of oil are reliably distinguished from untreated samples, but no meaningful preferences were expressed until the oil level in the emulsion was increased to 7.5%. In some cases, the judges indicated that textural differences (grain separation)

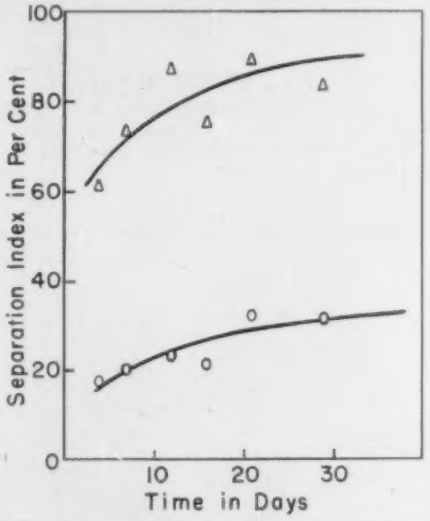

Figure 4. The effect of holding time at room temperature on separation index for untreated rice (circles) and emulsion treated rice (triangles).

TABLE 4

Effect of holding temperature on separation index for untreated and treated canned rice; stored 7 days

Sample treatment	Separation index, %					
	90° F	70° F	50° F	34° F	34° to 70° F[1]	70° to 34° F[2]
(Untreated)	9	17	31	55	40	32
0.5% emulsifier[3]	14	19	65	72	62	49
5% emulsion	38	77	92	91	91	87

[1] Stored 6 days at 34° F, one day at 70° F, and tested at 70° F.
[2] Stored 6 days at 70° F, one day at 34° F, and tested at 34° F.
[3] Sorbitan mono-oleate (Span 80).

TABLE 5

Organoleptic evaluation of rice treated with emulsions containing different concentrations of oil

Sample treatment	Judgments			Preference[1]	
	Total No.	No. correct	% correct	Control	Treated
2.5% oil emulsion rinse	19	12	59	5	8
5.0% oil emulsion rinse	20	17	84**	8	4
7.5% oil emulsion rinse	19	15	79**	14**	3

** Difference significant (P. 0.01).
[1] Some judges had, or expressed, no preference.

rather than flavor differences were used to distinguish between the samples. In any event, it would seem that canned rice treated with a 5% oil emulsion would be acceptable to the average consumer. By a ranking method the panel was unable to distinguish flavor differences among the 7 vegetable oils used in the treatments, but could detect differences between 3 emulsifiers when used by themselves in the rinse. With regard to flavor stability of emulsion treated canned rice, no significant differences had appeared after 19 weeks between samples held at 34° F and others held at 100° F. These stability experiments are being continued.

Effects due to differences in rices. Cooking qualities of rice have long been known to vary from year to year and with the age of a rice. In the present experiments, the behavior of a sample of 1957 crop rice approximately 17 months old was compared with a sample of 1958 crop rice about 5 months old. The results are as follows:

Treatment	Separation index, %	
	1957 crop	1958 crop
	(17 months old)	*(5 months old)*
Untreated	16	17
0.5% sorbitan mono-oleate	24	33
5% oil emulsion	53	75

These values do not permit a conclusion as to whether the differences are due to crop year, age, or both, but they emphasize the importance of care in selection of raw rice to obtain uniformity of product.

DISCUSSION

Changes during processing and subsequent aging of canned rice, which make it superior to freshly prepared short-grain rice, appear to be similar to firming or hardening in bread and other starchy systems often associated with retrogradation or crystallization of gelatinized starch. Hardening of rice kernels during the first few weeks after processing undoubtedly helps to prevent stickiness between kernels when subsequently prepared for serving.

At the same time, when adjacent kernels lie close together in the can, some of the hardening forces will also operate between the kernels so that coherent clumps or masses are formed. It is probable that films of emulsified oils act as a barrier to this process. Results with the canned samples stored at different temperatures suggest that the within-kernel changes occur more rapidly than the between-kernel effects. Masking or retardation of these inter-kernel effects reduces the undesired cohesiveness. The presence of an emulsifier with both hydrophilic and lipophilic properties seems to be essential, since oils alone are not satisfactory.

Experience in preparation of canned rice for market testing *(2)* indicates that presently available equipment can be adapted with only minor modification to the canning of rice including a dip rinse or a spray application of an emulsion or surfactant.

SUMMARY AND CONCLUSIONS

A rinse treatment with dilute vegetable oil emulsions or dilute dispersions of certain surface-active agents during the canning of short-grain rice markedly reduced the cohesion that normally develops in the product. Cold storage of the product after canning was also beneficial. Neither the type nor concentration of emulsifier in the emulsion influenced significantly the degree of cohesion in treated products. Emulsifiers differed in their effect upon cohesion when used alone, but no correlation with their type or structure was evident.

Reduction of cohesion in the rice was directly related to the logarithm of oil concentration in the emulsions. The amount of oil taken up by the rice reflected the concentration of oil in the emulsion but barely exceeded 1.0% even at a level of 15% oil in the rinse. When the level of oil was below 5% in the rinse, a taste panel could not reliably distinguish between treated and untreated rice. No change in organoleptic properties appeared in treated rice after 19 weeks of holding at 100° F.

Small though significant differences in cohesiveness were found among treated samples of milled rice of different age and crop year.

Acknowledgments

The authors wish to thank Marjorie Heid, who conducted the taste-panel evaluations. Appreciation is also expressed to the following companies for samples of commercial surfactants: Atlas Powder Co., Colgate-Palmolive Co., Central Soya Company, Inc., Distillation Products Industry, Emulsol Chemical Corp., Glyco Products Co., Process Chemical Co., and Procter and Gamble. Special oils were generously supplied by Durkee Famous Foods, Pacific Vegetable Oil Corp., and Rice Growers Association of California.

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Comminuted Orange

A Novel Process for Its Manufacture

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(Manuscript received July 28, 1959)

THE FACT that citrus peels contain more than twice the amount of ascorbic acid than the juice of the endocarpium *(4)*, as well as the fact that all of the essential oil is incorporated in the flavedo, lead some producers of citrus products to try ways and means for a fuller utilization of citrus fruit. One of these is to convert the whole of the citrus fruit into an edible product.

"Comminuted orange" is a recently coined term introduced into the trade dealing with citrus products. By this is generally meant transforming citrus fruit into a paste of more or less fine texture by means of some sort of disintegration. Apart from isolated articles *(1)* and news items in industry journals and a few patents, practically nothing has been published on this subject in the scientific or technical literature, but private communications reveal that most of the methods of manufacture at present used for comminuting citrus fruit are based on the following main steps: either whole citrus fruits, or the peel alone, or various proportions of juice, rag and peel are mechanically disintegrated and milled to a fine colloidal paste using suitable milling equipment. In some cases the milling is preceded by cooking the peel in double jacketed stainless steel tanks in order to soften it before comminution.

What is usually required of a good product seems to be:

a) practical sterility of the product,
b) proper colloidal consistency,
c) retention of vitamin C,
d) inactivation of pectolytic enzymes,
e) good keeping qualities.

However, all existing processes of manufacture seem to have distinct deficiencies and leave much to be desired in the final product.

The following novel process of manufacture of comminuted citrus fruits is described here after having been fully tried out on both a laboratory and a pilot-plant scale.

THE PRINCIPLE INVOLVED

Elsewhere, Braverman *(3)* has described a method for disintegrating plant material—in particular, fruits, using a modified Henze cooker which was originally widely used in Western Europe in the early years of this century for cooking and disintegrating potatoes in the production of alcohol.

This method *(3)* consists in steam heating whole fruits in a stainless steel, conical pressure cooker, as described below in detail, provided with a blow-out valve at the base. The contents are then blown out by sudden opening of the valve. The mass blown out in such a manner is completely disintegrated, because of the bursting of the vegetable cells. At the same time several important results are achieved: sterilization of the fruit; thorough disintegration; and simultaneous inactivation of the pectic and other enzymes. The mass is then passed over a finisher and through a colloidal mill, for final smooth consistency. It is then pasteurized and hot filled.

Equipment and process. The pilot plant equipment used in these experiments is 1 meter high and 40 cm at the widest base of the inverted cone (Figure 1) built of stainless steel with walls

Figure 1. Henze pilot-plant disintegrator.

3 mm thick. The upper cover is removable for introducing the fruit and has 8 hinged screws. This cover is provided with a vent, a pressure gauge and a safety valve. A wide grid in the form of a cross is inserted at the bottom of the conical apparatus, just above the outlet, to prevent whole fruit from clogging the opening.

The rapid opening blow-out valve at the bottom end of the conical cooker is 2 inches in diameter, proportionally wide

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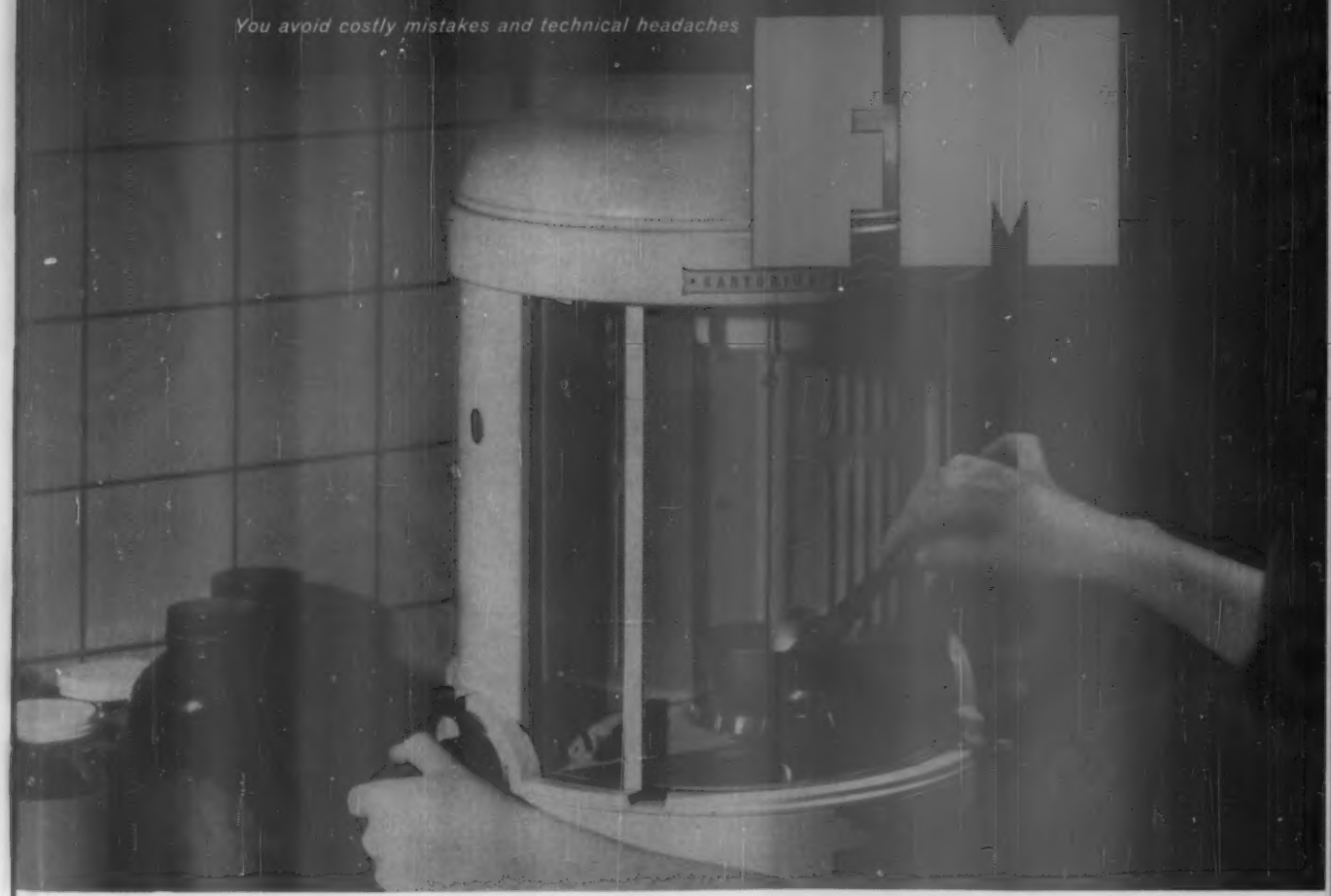

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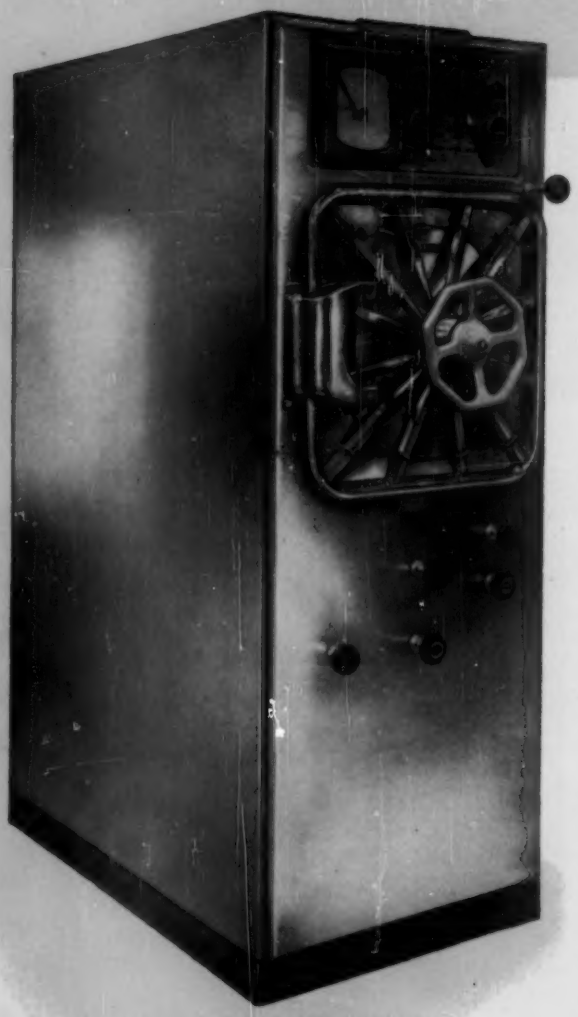

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enough to allow the entire mass through as fast and as freely as possible. Just above the blow-out valve a side tube ending with a tap projects from the bottom of the cooker—this is used for blowing out any condensate before the final blow-out (Figure 2).

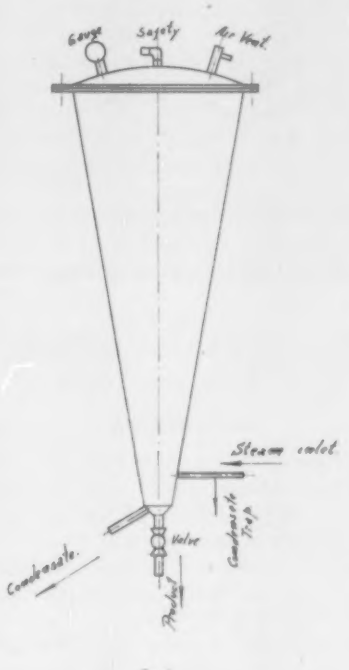

Fig. 2.

Figure 2. Henze disintegrator—drawing.

The conical pressure cooker, with the cover removed, is filled with adequately washed and trimmed whole oranges leaving some headspace. The cover is now carefully screwed on. With the air vent open live steam is now introduced into the apparatus until the air of the cooker is entirely replaced by steam. To prevent excessive dilution of the resulting product with steam condensate, the side tube is now opened to release all accumulated condensate. The fruit is not ready for processing. The air vent is closed, as is the tap of the condensate. Steam pressure is now raised to 3 atmospheres (approximately 40 lb per sq in). The holding time naturally depends on the amount of fruit in the apparatus, but 2 to 3 min are generally sufficient. At the end of this period the steam inlet is shut off and the blow-out valve at the bottom of the cylinder is quickly opened discharging the entire contents of the cooker. The high temperature to which the fruit is subjected in the pressure cooker is immediately reduced as soon as the blown out mash of oranges is released into the receiving tank.

The mash, while still warm, is transfered now to an ordinary finisher (screen with 1 mm perforations) where all seeds, green buttons, and the greater part of fragments of the parenchymatous walls of the segments are largely removed. The screened material from the finisher can normally be packed as it is. However, most buyers prefer a smoother texture and, therefore, the mass is passed through a colloidal mill (Figures 3 and 4) from which the final material emerges having perfect colloidal consistency.

The comminuted final material was packed in plain number A 2 and in 6 oz lacquered tins and pasteurised at 95° C for 20 and 10 minutes respectively. Other batches of the material were preserved with 2000 pp SO_2 in jars and barrels.

Figure 3. "Frima" colloidal mill—external view.

RESULTS

Samples of comminuted fruit prepared by the above process had on the average the following indices:

Specific gravity at 20° C	1.034 W/V
Total soluble solids	14° Brix
Acidity (as Citric Ac.)	0.4%
Ascorbic acid	47.5 mg/100 g
Essential oil	1°/oo (per mille)
Viscosity (flow in standard tube 1 cm in Ø	6' 21"
Jelly test	no PE activity

On storage at ordinary room temperatures the product had excellent keeping qualities, its yellowish colour and fine texture persisting. The flavour remains very pleasant and no deterioration of the essential oil has been observed even on prolonged storage.

Ascorbic acid content of the paste which was on the average 60 mg/100 g at the point of being blown out from the pressure-cooker was quickly reduced to about

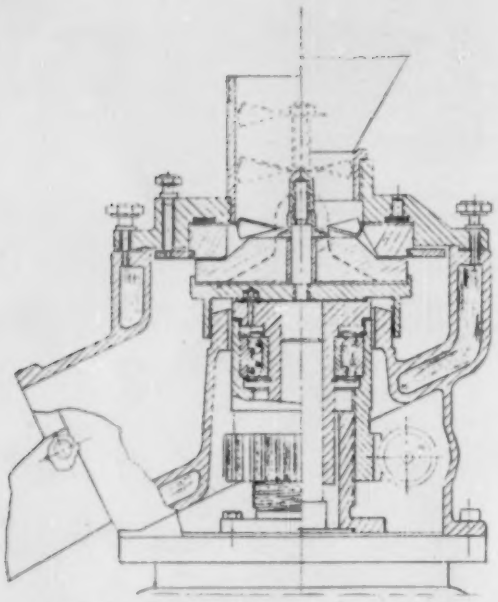

Figure 4. "Frima" colloidal mill—drawing.

47 mg/100 g during the colloidal milling when a large amount of air is usually incorporated.

Thereafter, however, there was no loss of vitamin C in the product packed in plain tinned cans and that preserved with SO_2 in barrels, but all samples packed in lacquered tins underwent losses as shown in Figure 5.

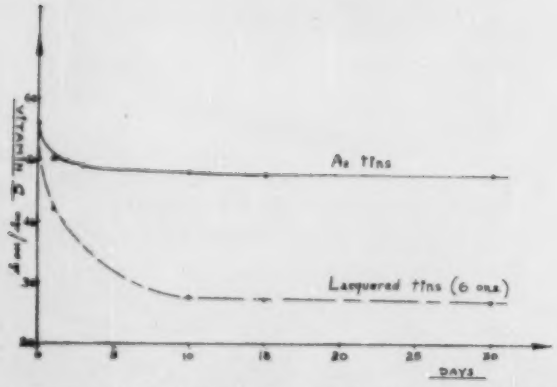

Figure 5. Loss of vitamin C in comminuted orange packed in cans (plain and lacquered).

While the Jelly test after the process is negative showing no activity, the product shows a marked diminution in viscosity as shown in Figure 6.

While the whole orange of the Jaffa variety contains around 3 per mille by weight of essential oil of orange it is only to be expected that the use of this process reduces the quantity of essential oil left in the final product and this naturally is due to partial steam distillation of the oil during the blowing out operation. The residual oil content is always slightly above

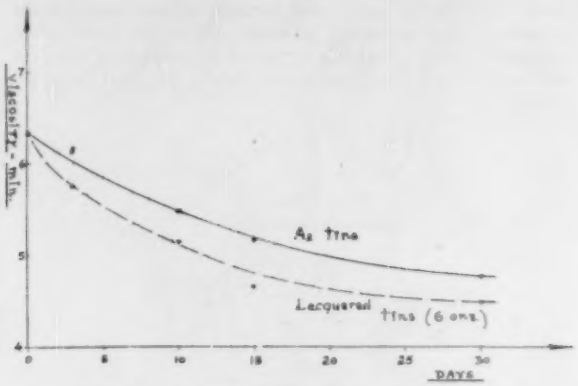

Figure 6.—Viscosity of comminuted orange on storage.

1°/oo, however, but this quantity remains very stable as discussed further.

DISCUSSION

When designing the pressure cooker it is important that the whole column should end in a smooth and gradual cone. If the bottom of the heating chamber is straight or only rounded it will create considerable obstruction to the material blown out. This will result in the steam forcing a passage out and leaving part of the fruit in the cylinder.

Both pressure and holding time must be checked separately for every apparatus as well as for every individual plant material to be processed.

The Henze pressure cooker causes the complete and rather fine disintegration of the citrus fruit tissue through the bursting of all vegetable cells when the blow-out valve is suddenly opened. While soft fruits, such as apricots or pears, require a lower temperature-pressure, citrus fruits require a pressure of about 40 lb psig for about 3 min. All experiments in this work have been carried out on the Jaffa (Shamouti) variety, mainly grown in this country and on the Late Valencias. These latter required a somewhat longer time for complete disintegration, 3½ min. But even larger pieces which are torn away from the fruit during the distintegration are so soft that they are easily comminuted already in the finisher.

The second achievement of the Henze apparatus in this case is the complete sterilization of the product during this process. Any contamination which the comminuted paste may acquire from this point onwards occurs only during the subsequent finishing operation and colloidal milling.

A number of sterility test made on the final product were invariably negative.

It is obvious that such treatment of the plant material completely inactivates all present enzymes and among them those particularly important in citrus fruits, the pectolytic enzymes, pectin esterase (PE) and poly-galacturonase (PG). When mixed with any juice or syrups the final product makes very good dispersions which keep well. The permanent cloud stability is not disturbed even on prolonged storage

during the first few weeks of which the apparent viscosity usually tends to decrease.

The stability of ascorbic acid in the product packed in plain tins is due of course to the reducing power of the tin coating.

The most remarkable feature of this product is the stability of the essential oil in the paste at a level of 1°/oo or higher, which keeps well even on prolonged storage without undergoing any sort of rancidity or the ACHD (acid catalyzed hydration-dehydration) described by Blair *et al. (4)*, such as is usual in these cases. The only plausible explanation for this stability of citrus essential oil in an acid medium is that into it is closely incorporated quite a high quantity of bioflavonoids which most probably act here as antioxidants—a point which is worth pursuing further.

SUMMARY

A novel process for the manufacture of comminuted citrus fruits has been investigated. The process consists in heating whole oranges in an Henze apparatus and blowing out the contents, and subsequently finishing and milling the final product. Several important qualities in the final product have been attained by this process: complete sterility of the product, disintegration without mechanical means, and finally inactivation of enzymes. The keeping qualities of the product are described.

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An Evaluation of the Indole and Trimethylamine Tests for Oyster Quality

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No simple and dependable tests for oyster quality are presently available. Extreme biological differences, seasonal variations, and use of the whole organism in the tests complicate the analytical problems. Need for a measure of oyster quality, long recognized by the industry and by public health officials, has prompted numerous investigations. Most of this research has failed to fulfill the need, but tests for indole and trimethylamine have recently been proposed as possible spoilage indices for oysters. Since indole is formed during the decomposition of proteins, it has been assumed that indole content might parallel spoilage.

Clarke and co-workers *(4)* exhaustively investigated and improved the procedure for isolation and determination of indole. This procedure was used by King *et al. (10)* to study decomposition in canned oysters. They reported increases in indole content from 1.0 to 5.3 mcg per 100 g of oyster meats when washed oysters were stored for 288 hr at 20 to 25° C. Indole content at the onset of spoilage was 1.8 mcg per 100 g of oyster meats. Very high indole contents were reported in unwashed oysters stored under the same conditions.

Beacham *(2)*, who reinvestigated the relation of indole content to spoilage after making a few modifications in the procedure, reported indole concentrations as high as 144 mcg per 100 g of oyster meats in oysters which he described as having "a strong odor of decomposition."

Another comprehensive study of the test was made by Duggan and Strasburger on shrimp *(7)* and by Duggan on oysters *(6)*. These investigators modified the procedure further, and their final modification has been accepted as an official method of analysis of the Association of Official Agricultural Chemists *(12)*.

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Duggan studied the reproducibility of the test and concluded that it was sufficiently precise to qualify as an index of oyster quality.

The trimenthylamine test of Dyer *(8)* has been employed with some success in quality studies on shrimp by Fieger and co-workers *(9)*. Novak *et al. (11)* reported some favorable results on oysters and postulated that this may be a possible test for oyster quality.

Chlortetracycline (CTC) has been studied as an effective preservative for many food stuffs and has been tested as a preservative for oysters by Abbey and co-workers *(1)*, Boyd and Tarr *(3)*, and Novak *et al. (11)*. The latter found that an oyster dip of 20 ppm CTC for 2 min increased the storage life of ice-stored oysters by several days; similar results were obtained in the other laboratories. Boyd and Tarr *(3)* reported an initial uptake of the CTC by oysters subjected to these conditions to be 1.30 ppm. This concentration decreased 50 to 60% during a 12-day storage period. Microbiological growth was decreased by use of the antibiotic.

The experiments herewith reported were designed to: (1) ascertain the applicability of the indole and trimethylamine tests for oysters, modifying them when necessary, (2) evaluate these tests as indices of oyster quality by comparing them to bacterial counts and organoleptic ratings at various stages of oyster decomposition, (3) determine the effect of CTC as a preservative for oysters, and (4) the effect of CTC on these tests and on the spoilage mechanisms of oysters as evidenced by indole and trimethylamine formation.

EXPERIMENTAL

Description of oyster quality tests. All analyses were made on samples obtained from an oyster plant in New Orleans. The oysters were from various beds off the Louisiana Gulf Coast. In all cases these oysters had been tonged the day before the experiments began. They were hand shucked, packed unwashed in metal containers, placed in crushed ice in insulated hampers, and transported by automobile to the Laboratory in Baton Rouge. The time interval between shucking the oysters in the plant and processing them in the laboratory did not exceed 6 hours.

1. Oyster Quality Test I. Two pints of freshly shucked oysters were washed with cold tap water for 2 min and allowed to drain for 5 min. They were divided and processed as follows: one half was washed in a 20 ppm solution of CTC for 2 min and then drained in a colander for 5 min. The other half, the untreated control, was washed in tap water for 2 min and drained as above for 5 min. Each sample was returned to its original pint can and stored in crushed ice in the hamper in a cold room at 5° C. Samples of oyster meats were removed at selected intervals, rated organoleptically, and analyzed for indole.

2. Oyster Quality Tests II and III. It was observed in Trial I that oysters lost a considerable amount of liquid during storage. It was decided in these trials to base analyses on an original drained weight of the oysters, and to analyze the liquid lost during the interim of storage as well as the meats.

Three pints each of control and of CTC treated oysters were used in each of the 2 trials. These oysters had been processed exactly as those in Trial I, except that after draining, about 100 g of oysters were weighed to the nearest gram and transferred to glass screw-top jars for storage in ice as before. The samples were kept well iced throughout the experiment and were repacked every 6 days to maintain constant storage conditions.

Two jars of the CTC treated oysters were removed at 6-day intervals. Liquid measurements were taken on each of the jars. The free liquid, washings from the sieve, pan, and jar, and the meats from one jar were combined in a Waring blender, homogenized, divided in half, and each half was steam distilled for the indole test.

A sample of oysters (about 30 g) was removed after draining the oysters from the other jar and used for the bacterial count. The remaining oysters and free liquid were combined and blended for 2 min. (The jar, sieve, and pan were not washed in this case.) Two 25.0 g samples were removed and steam distilled for the trimethylamine determinations.

The same procedure was carried out for the control oysters.

Determination of indole. The indole test used was essentially that of Duggan *(12)* with the following modifications:

1. An easier method for the purification of the p-dimethylaminobenzaldehyde (p-DAB) was substituted.

A portion of p-DAB was dissolved in boiling absolute methanol and decolorized with charcoal. The mixture was filtered hot through a Buchner funnel, and the charcoal was washed with 2 fresh portions of hot methanol (no suction was used during the washings). After transferring the clear pale yellow liquid to another container, the p-DAB was precipitated by the addition of distilled water, collected on a Buchner funnel using minimum suction, and dried in a desiccator over silica gel at reduced pressure.

It was found that 2 recrystallizations were necessary to obtain a pure white product.

2. Dow-Corning Antifoam Agent—AF was used in the distillation to prevent foaming.

3. Preliminary experiments showed that nearly complete (96.6%) recovery of the indole could be obtained by increasing the volume of the distillate collected from 350 to 450 ml.

4. The saturated Na_2SO_4 and the dilute HCl solutions used in the extractions can be mixed in equal proportions and stored without any adverse effects. Ten ml of this solution were employed instead of 5 ml of each as stated in the procedure *(5)*.

5. A standard curve was prepared by steam distilling aliquots of a known indole solution. Indole used for this solution was recrystallized from hot water and dried over silica gel at reduced pressure.

Determination of Trimethylamine (TMA). The procedure of Dyer *(8)* was selected, but extraction of the oysters with 5% trichloracetic acid was not used since this also extracted another substance (s) which resulted in a yellow precipitate in the final step of the procedure. Extractions with tungstic acid, phosphomolybdic acid, phosphotungstic acid, and absolute ethanol were tried unsuccessfully in an attempt to eliminate the interfering agent. Since this difficulty was not encountered in previous use of the test in this laboratory *(11)*, it is postulated that the interfering agent may be an environmental or seasonal constituent in oysters. Therefore, the TMA was extracted from the samples by steam distillation.

A 25.0 g sample of oysters was homogenized in a Waring blender for 2 min and transferred quantitatively to the distillation flask by washing the blender with a minimum quantity of water. The same distillation apparatus required for indole was used. Dow-Corning Antifoam Agent—AF was added. The spray trap was inserted into the distillation flask and attached to the condenser connection with a piece of Tygon tubing. A 400 ml beaker containing 100 ml of approximately 1 *N* HCl was placed so that the end of the condenser was below the level of the acid.

After the water was boiling in the steam generator, 100 ml of 10% NaOH was added to the distillation flask through the steam inlet tube which was then connected to the steam generator with a piece of Tygon tubing. Sufficient heat was applied to the distillation flask to maintain a volume of about 150 ml, and distillation was continued until approximately 125 ml of distillate was collected (about 20 min).

The liquid in the beaker was transferred to a 250 ml volumetric flask and made up to volume with water. One to 4 ml of this solution was transferred to a thiamine tube and extracted as outlined in the procedure by Dyer.

The extraction step should begin as soon as possible after distillation since deteriorative changes occur in the distillate

which within 10 hr impart a brownish color to it. A 35% decrease in TMA content was observed within a 24-hr period.

The standard curve was prepared by steam distilling known quantities of trimethylamine hydrochloride which had been dried over P_2O_5 prior to making up the standard solutions.

All glassware, with the exception of the distillation apparatus, must be washed with 10% acetic acid followed by soap and water to avoid contamination. It should be noted that the toluene used in the extractions can be recovered by washing with water in a separatory funnel until no trace of a yellow color remains, followed by 3 additional washings with distilled water, and drying over Na_2SO_4.

Bacterial plate counts. Bacterial plate counts were determined by the following procedure: Weighed samples of oyster meats were mixed with an equal amount of sterile distilled water and blended in a sterile Waring blender. Serial dilutions were made, and aliquots were plated in triplicate on Difco Nutrient Agar and incubated for 3 days at 28° C. Total colony counts were made with the aid of a Quebec colony counter and results expressed as number of organisms per gram of oyster.

Determination of per cent liquid. In trials II and III the oysters were stored in individual glass jars each containing a weighed sample of oysters. Each jar was poured into a regular household sieve and allowed to drain for exactly 5 min into a tared pan. Weight of the liquid was determined and the per cent liquid on the basis of the original drained sample was calculated.

Organoleptic ratings. Oysters were appraised by 2 judges as to presence of off-odors, black spots, general appearance, and texture of the meats. The following classes were devised to classify the oysters:

Class A—oysters fresh and free from any undesirable characteristics.

Class B—oysters beginning to show signs of spoilage; weak off-odors, darkening of oysters, and black spots evident.

Class C—oysters inedible; exhibiting definite off-odors, very mealy flesh, and general darkening of the meats.

RESULTS AND DISCUSSION

Indole determination. In all three oyster quality tests indole concentrations decreased during the first 6 days of storage. This drop occurred in both the CTC treated oysters and the control samples. After this period the indole contents do not exhibit any obvious or consistent pattern.

In trial I (Table 1) the indole content of the oyster meats tended to level off with the control oysters containing slightly less indole than the CTC treated oysters until the 20th day when the indole content of the control oysters increased. This experiment was designed to last only 20 days since the indole content was expected to exhibit significant changes during the time prior to oyster spoilage.

In trials II and III (Tables 2 and 3) the indole contents showed both increases and decreases occurring within a 6-day interval. A check was made on the sampling techniques on the final sample in trial II. Analyses of indole, TMA, bacterial count, and liquid were made on triplicate samples of both CTC treated and control oysters. Results obtained agreed within experimental error and showed that the previously obtained results were valid and indicative of the complete oyster sample.

These results do not indicate deterioration in quality or onset of spoilage, which on the basis of organoleptic ratings occurred about the eighteenth day in all cases, nor do they give any evidence of the effective nature of CTC in preserving oysters other than maintaining reduced bacterial counts. This test cannot be recommended as a quality test for oysters on the basis of these findings.

King has stated that small amounts of indole are produced in washed oysters, and this was substantiated by the results of this investigation. However, with one exception, he reported a gradual increase in the indole content throughout the storage period. This was probably due to a different type of spoilage from that occurring in these experiments.

Unwashed oysters have been observed by Beacham to produce indole in large quantities. Since surface microorganisms have not been removed in unwashed

TABLE 1

Results of oyster quality test I

Days storage	Sample	Indole (mcg/100 g)[1]	Organoleptic
0	.....	4.19	A
6	CTC	3.70	A
	Control	3.45	A
12	CTC	3.70	A
	Control	3.45	B
20	CTC	3.35	C
	Control	4.44	C

[1] Based on oyster meats only.

TABLE 2

Results of oyster quality test II

Days storage	Sample	Indole (mcg/100 g)	TMA-N[1] (mg/100 g)	Bacterial count (x 10^6) per gram	Liquid[1] %	Organoleptic
0	.....	3.18	0.73	0.065	.....	A
6	CTC	2.96	1.27	0.104	10.8	A
	Control	2.90	1.19	0.139	11.0	A
12	CTC	2.38	1.39	0.507	10.0	A
	Control	1.50	1.82	0.864	10.5	B
18	CTC	2.69	1.13	3.42	13.5	B
	Control	4.24	1.25	8.17	13.5	B
24	CTC	1.87	1.61	12.1	15.0	C
	Control	3.58	1.35	39.4	17.1	C
30	CTC	3.20	1.19	63.7	15.3	C
	Control	1.98	0.89	91.0	18.1	C

[1] Based on original drained weight of oysters.

TABLE 3

Results of oyster quality test III

Days storage	Sample	Indole[1] (mcg/100 g)	TMA-N[1] (mg/100 g)	Bacterial count (x 10^6) per gram	Liquid %	Organoleptic
0	.....	4.14	0.86	0.087	5.7	A
6	CTC	2.20	1.37	0.210	6.6	A
	Control	3.72	1.21	0.204	8.5	A
12	CTC	4.59	0.91	0.755	12.1	A
	Control	2.62	1.12	1.11	9.3	B
18	CTC	3.16	0.90	7.72	14.1	B
	Control	1.46	0.80	10.3	12.9	C
24	CTC	3.82	1.20	26.3	14.1	C
	Control	1.40	1.12	42.0	16.2	C
30	CTC	2.09	1.33	85.0	14.8	C
	Control	1.78	1.25	100.0	17.1	C

[1] Based on original drained weight of oysters.

oysters, they probably contributed to a type of decomposition resulting in increased indole formation.

Trimethylamine test. TMA as stated earlier, was not determined in trial I. In trials II and III (Tables 2 and 3) complete randomness is evident after an initial rise in all 4 samples. Since there is no obvious or definite trend in the results, TMA content is not useful in predicting oyster quality, nor is it valuable as a measure of the preservative qualities of CTC in oysters.

In most instances an increase in indole concentration is accompanied by a decrease in TMA concentration and *vice versa*. It was postulated that a possible correlation existed between the two variables but an insignificant correlation coefficient obtained statistically invalidated this theory.

Bacterial counts. Slight contamination of the oysters by bacteria from the air may have occurred during determination of the liquid, but this is believed to be of minor importance since the area in the air-conditioned laboratory where the measurements were taken is extremely low in microorganisms.

The counts (Tables 2 and 3) are definitely indicative of oyster quality, and in both trials II and III spoilage was evident when the counts were approximately 10 million organisms per gram of oyster meat. CTC limited the count in both trials, and the effect of the antibiotic began to decrease after approximately 24 days.

Bacterial count alone is an inadequate method of determining decomposition of a sample due to many factors. However, in samples where the history of the oyster is known, it is a valuable measure of oyster quality.

Liquid measurements. Values in Tables 2 and 3 give an estimate of the amount of liquid lost from the oysters during storage. The volume with a few exceptions increased steadily throughout the storage period, and at the onset of spoilage was about 13%.

Organoleptic ratings. Deterioration was evidenced by a gradual increase in the occurrence of black spots, off-odors, a general darkening of the whole oyster, and a decrease in the firmness and texture of the oyster. Chlortetracycline delayed the development of off-odors for a few days. There were no objectionable results observed from the oysters washed with the antibiotic.

SUMMARY

Indole and trimethylamine tests were investigated for applicability as quality tests for freshly-shucked and refrigerated oysters. Some modifications were made which were necessary for adapting these tests to oysters, and these modified tests were found to be accurate and reproducible. Both are sensitive and capable of detecting microgram quantities of the compounds.

These determinations along with bacterial counts, liquid measurements, and organoleptic ratings were employed in oyster quality tests, and their value as indices of oyster spoilage was determined. Since indole and TMA concentrations showed no definite pattern during storage, these tests are not recommended for assessment of oyster quality.

Bacterial counts and liquid measurements closely parallel organoleptic ratings. Spoilage was usually evident from the eighteenth to the twentieth day of storage, and the oysters at this time had bacterial counts of about 10 million per gram, and had decreased in weight by about 13% due to the loss of fluid from the meats.

The effects of CTC on these tests and on extending the storage life of oysters were also investigated. The antibiotic did not interfere with the tests, nor did it suppress the formation of indole and TMA; but it did limit the bacterial count, and the development of off-odors.

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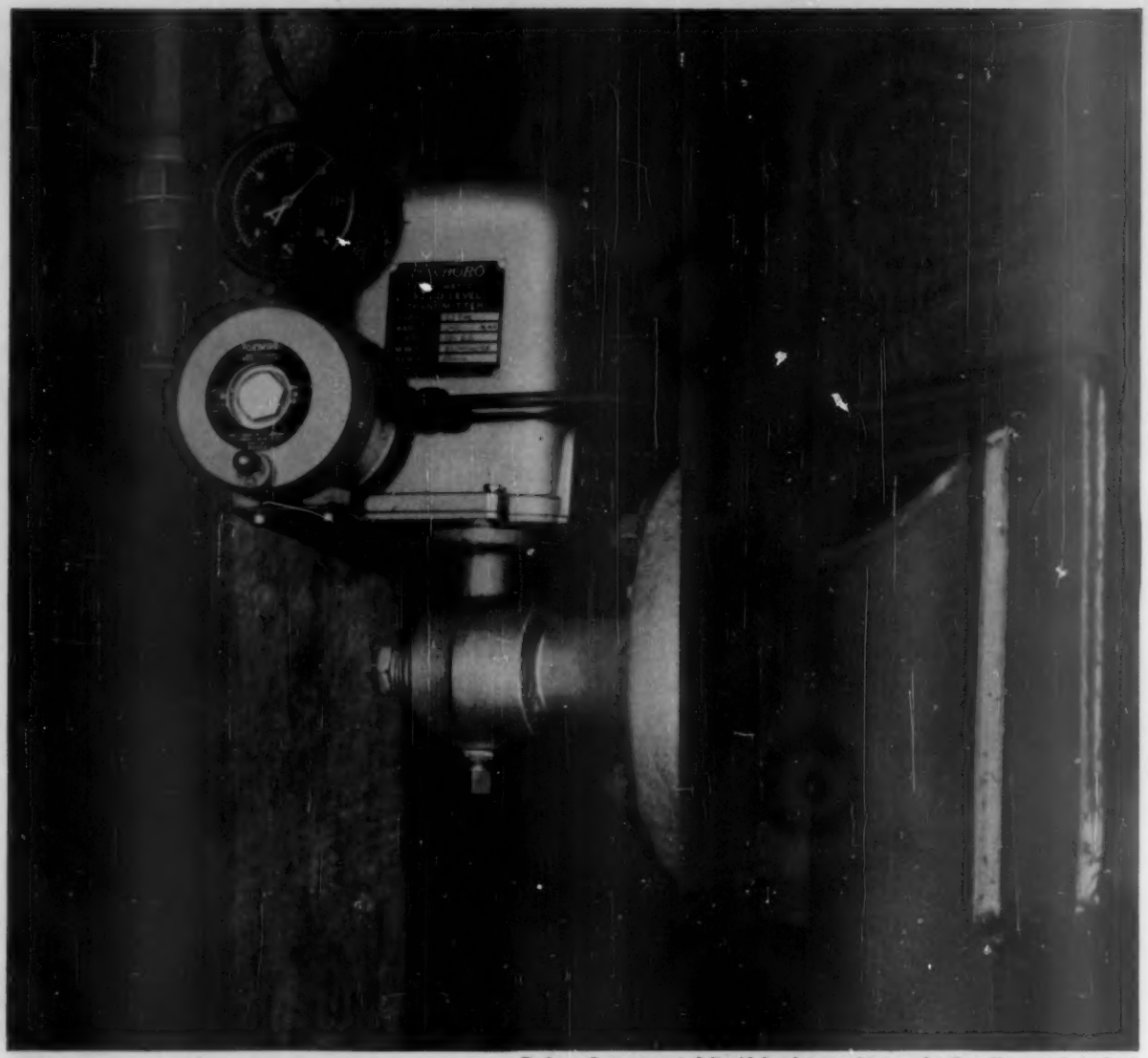

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Preservative Effect of Some Antimicrobial Agents on High-Moisture Dried Fruits

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In recent years, the dried fruit industry of California has increased the moisture content of a substantial portion of the total pack of dried prunes and dried figs. It is likely that the trend to higher-moisture products will embrace other dried fruits, particularly raisins. Consumer demand for high-moisture dried fruits has been the main reason for this trend. High-moisture dried fruit products are very tender, moist, and palatable and can be eaten out of hand. Production of these fruits is thus part of the general trend toward ready-to-eat and convenience foods.

The high-moisture dried fruits, however, are more susceptible to spoilage by mold and yeast than are dried fruits at lower moisture levels. Reported here are experiments to evaluate a number of preservatives, including some already in use for preservation of other food products. Individual packers should consult the Food and Drug Administration, Washington 25, D. C., and the food and drug officials of the individual states involved to determine whether or not the use of any proposed additive is permissible and, if so, what limitations are placed on its use.

Although it was intended to include all dried fruits, it became apparent that initially this study should confine itself to the one dried fruit which at present is the major user of such preservatives; namely, prunes. The results can be checked on high-moisture figs and high-moisture raisins when the latter become available.

Five preservatives were used. They were propylene oxide (Distillation Products, Inc., Eastman Kodak), potassium sorbate (Union Carbide Chemical Co.), calcium propionate (Monsanto Chemicals Co.), vitamin K_5 (Nutritional Biochemical Corp.), and dehydroacetic acid (sodium salt) (Dow Chemical Co.)[d].

Bell *et al. (1)* and Beneke *et al. (2)* have reported on the action of sorbic acid as a growth inhibitor to mold and bacteria. Calcium propionate was shown to inhibit growth of mold on butter in work reported by Csiszar *et al. (3)*. The use of dehydroacetic acid as a food preservative has been described by Eeckhault *(4)* and by Pratt *et al. (5)*. Yang *et al. (8)* reported satisfactory results from the use of vitamin K_5 as a preservative in wine. Control of microbial spoilage in foods by fumigation with epoxides was described by Whelton *et al. (7)*.

MATERIALS AND METHODS

About 200 lb of large, processed, high-moisture prunes (35% flesh moisture) without added preservatives were obtained from a commercial packaging house. Individual lo's of about 15 lb were submerged for 2 min in solutions of different concentrations of potassium sorbate, calcium propionate, dehydroacetic acid, and vitamin K_5. The treated prunes were placed on stainless-steel screens to drain off the excess solution and then were thoroughly sprayed with a suspension containing a mold *(Aspergillus glaucus)* and a yeast *(Saccharomyces rouxii)*. The mold and yeast cultures used for inoculating the samples were isolated from spoiled prunes. They represent the predominant species found in a survey of the flora associated with spoiled prunes.

The propylene oxide samples were submerged for 2 min in water, drained, and inoculated as above: 0.75 ml of propylene oxide was added to the package just before sealing. This amounts to 1.5 ml of propylene oxide per pound of fruit, which is the amount usually used commercially for high-moisture prunes. The control group was merely dipped in water for 2 min, drained, inoculated, packaged, and sealed. The samples were packed in ½ lb portions in transparent Durafilm bags, sealed, and incubated at 78° F and 80% RH. The samples were examined periodically for visual evidence of mold or yeast growth in the unopened packages.

The concentrations of the preservatives used were:

Potassium sorbate	20%, 10%, 5%, 2%
Calcium propionate	5%, 2%, 1%, 0.5%, 0.2%
Dehydroacetic acid (sodium salt)	3000 ppm, 1500 ppm
Vitamin K_5	2000 ppm, 1000 ppm
Propylene oxide	1.5 ml per lb

RESULTS AND DISCUSSION

Periodic inspection of the bags of prunes for visual manifestation of growth revealed obvious differences in amounts and rates of growth of micro-organisms. The results in Table 1 show that potassium sorbate was a most effective anti-mycotic agent when used in the manner described above. The sorbate is soluble and easy to handle in the processing line. Vitamin K_5 had some undissolved materials in it. This insolubility and a bluish color which developed in the dipping bath would militate against its use by industry. Calcium propionate is soluble in water but at the higher concentration (5%) had an unpleasant odor that was noticeable to some persons.

Table 1 shows that under the experimental conditions used, dipping prunes in 2% potassium sorbate protects against mold and yeast at least as effectively as propylene oxide in the concentration now used. The untreated samples were badly spoiled in 10 days. Fermentation had taken place to the extent that the

[a] Collaborator employed by the California Raisin, California Fig, California Prune Advisory Boards and Dried Fruit Association of California, with whom this work was conducted cooperatively.

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[c] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

[d] Names of companies and products are given for convenience and do not constitute endorsement by the U. S. Department of Agriculture.

TABLE 1

Mold and yeast growth in high-moisture prunes treated with preservatives

Treatment	Mold and yeast growth [1]							
	5 days	10 days	15 days	20 days	25 days	30 days	40 days	60 days
Control (untreated)	+++							
Propylene oxide (0.3%)	–	–	–	–	–	+*	+*	+*
Vitamin K₃ (0.1%)	++	++	+++					
Vitamin K₃ (0.2%)	–	–	+	++	+++			
Dehydroacetic acid (0.15%)	–	–	++	+++				
Dehydroacetic acid (0.3%)	–	–	–	+	++	+++		
Calcium propionate (0.2%)	+	+++						
Calcium propionate (0.5%)		–	+	++	+++			
Calcium propionate (1%)	–	–	+	++	+++			
Calcium propionate (2%)	–	–	–	–	++	++	+++	
Calcium propionate (5%)	–	–	–	–	–	–	–	
Potassium sorbate (2%)	–	–	–	–	–	–	–	–
Potassium sorbate (5%)	–	–	–	–	–	–	–	–
Potassium sorbate (10%)	–	–	–	–	–	–	–	–

[1] Meanings of symbols: * = 2 bags only spoiled; +++ = all samples spoiled; ++ = about half spoiled; + = ¼ or less spoiled; – = no mold or yeast growth.

bags were ballooned with gas and an abundant growth of micro-organisms was visible on the surface of the prunes (Figure 1). After 60 days there was no spoilage in the prunes dipped in 2% potassium sorbate. Only 2 bags out of 30 treated with propylene oxide showed mold or yeast growth before 60 days. The seals of the bags that failed were not tested for leakage. In commercial usage, propylene oxide is virtually 100% effective. The samples treated with other materials (except 5% calcium propionate) were all spoiled considerably before 60 days of storage.

The residual effect of propylene oxide and potassium sorbate were tested by allowing opened packages to stand at 78° F and 80% RH. The samples were examined periodically for growth of micro-organisms (Table 2). After 20 days the samples treated with propylene oxide had all spoiled. It is known, however, that propylene oxide does not have a residual anti-mycotic effect and thus could not prevent spoilage in open packages. Samples dipped in 5% and 2% potassium sorbate were free of growth at 20 days.

Table 3 shows the results of analyses of whole prunes and prune skins for potassium sorbate. The amount of potassium sorbate picked up by the fruit

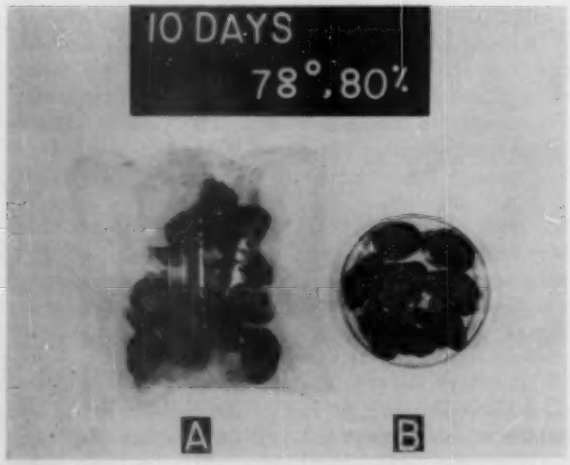

Figure 1. Control (untreated) samples of high moisture prunes: A. Prunes in sealed bag showing ballooning; B. Prunes showing surface growth of yeast and mold.

TABLE 2

Mold and yeast growth on open packages of prunes

Treatment	Extent of growth [1] Days open	
	10	20
Potassium sorbate, 2%	–	–
Potassium sorbate, 5%	–	–
Potassium sorbate, 10%	–	–
Propylene oxide	+	++

[1] Meanings of symbols: – = no growth; + = growth in half of the bags; ++ = growth in all of the bags.

did not change after repeated use of the potassium sorbate bath following dipping of 50 different batches of prunes.

TABLE 3 [1]

Potassium sorbate [2] pick-up on dried prunes

(Average of duplicate determinations)

Sample	Potassium sorbate	
	Whole prune	Skins
	%	%
Control	0.0081	0.0084
Control + fungistat [3]	0.0069	0.0073
Dip in 1% potassium sorbate	0.021	0.020
Dip in 5% potassium sorbate	0.063	0.072

[1] These data provided by Chas. Pfizer Co., Inc., by private communication from J. J. Geminder.

[2] Potassium sorbate in this study is identified as Sorbistat-K (Chas. Pfizer Co., Inc.).

[3] The fungistat used contained Fumold (McLean A. Neil Co., Inc.).

Triangle taste comparisons were made between prunes treated with propylene oxide and those dipped in various concentrations of potassium sorbate. Tastings were done by 10 experienced judges, each judge appraising 2 sets of samples (two triangles). The prunes dipped in 10% potassium sorbate were distinguished from those treated with propylene oxide in 65% of the tastings, which is considered to indicate a significant difference between the samples. However, prunes dipped in 5% and in 2% potassium sorbate were distinguished from the propylene oxide treated in only 40% of the judgments; this indicates that the samples were not significantly different.

SUMMARY

Several preservatives for high-moisture prunes were tested by incubating treated and inoculated samples.

Potassium sorbate and propylene oxide were found to be the most effective. Calcium propionate, dehydroacetic acid, and vitamin K_5 were considerably inferior under the conditions of these experiments. Potassium sorbate was found to have a residual effect in that the treated prunes did not spoil in open packages.

Acknowledgment

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Notes and Letters

A Note on the Effect of Various Temperatures on Some Characteristics of Pie Doughs

The effect of time and temperature on the organoleptic characteristics of pies and pie crusts has already been evaluated by various investigators *(2, 6)* but these studies include little information on the chemical changes which may occur in the pie doughs. The marked variations in composition and baking properties of flours from different wheats and particularly the differences in lipase activity reported for flours of different grades or extraction *(5)* suggested that such factors might affect the chemical properties of frozen pie dough. However, preliminary investigations described in this communication have indicated that chemical changes occur very slowly in doughs held at 3 different temperatures, provided mold growth remains at a low level.

Pie doughs were prepared *(4)* from a commercial pastry flour and from experimentally milled "shorts," (a wheat by-product containing considerable proportions of bran and germ). A portion of the dough prepared from commercial pastry flour contained sorbic acid to the extent of 0.07% of the dough weight. One lot of a commercially produced dough was also obtained. All doughs were rolled to a thickness of approximately ⅛-in, sealed in wax paper, placed in closed cans, and held at temperatures of approximately 39°F (4° C), 19° F (−7° C), and 0° F. (−18° C). Periodically, dough samples were lyophilized and tested. The dry samples were extracted with petroleum ether in a Soxhlet apparatus and the extracted fats were analyzed for free fatty acids *(7)*. The residue was analyzed for total reducing substances *(1)*. Mold counts were made on the whole dough immediately upon removal from the holding container. The procedure of Houston *et al. (3)* was used.

Table 1 shows data obtained for pie dough samples held at the 3 temperatures. In a relatively short time, changes occurred in the pie doughs kept at 39° F (4° C). A low level of lipolysis was observed in dough samples containing the fungistatic agent. In samples without the fungistatic agent, molds increased rapidly and caused appreciable hydrolysis of sample fat. No increase occurred in mold counts of any of the pie doughs held at 19° F (−7° C). Slight increases in free fatty acids occurred in both samples of doughs prepared in the laboratory with and without fungi-

TABLE 1

Effect of time and temperature on fatty acids, reducing substances and mold content in pie doughs

	Time, wks.	Fatty acids[1]	Total reducing substances[2]	Mold[3]
Dough held at 39.2° F (4° C)				
Laboratory dough	0	0.013	0.58	0.1
	2	0.039	0.72	0.1
	6	0.103	1.05	1.7
Laboratory dough with fungi static agent	0	0.018	0.42	0.1
	13	0.052	1.32	0.1
Commercial dough	0	0.021	1.87	0.1
	6	0.074	2.27	Too numerous to count
Laboratory dough containing "shorts" fraction	0	0.047	.....	0.1
	2	0.087	.....	Too numerous to count
Dough held at 19.4° F (−7° C)				
Laboratory dough	0	0.014	0.50	0.1
	94	0.065	1.76	0.1
Laboratory dough with fungi static agent	0	0.011	0.51	0.1
	94	0.066	1.86	0.1
Commercial dough	0	0.021	1.87	0.1
	94	0.043	2.92	0.1
Dough held at −0.4° F (−18° C)				
Laboratory dough	0	0.011	0.50	0.1
	94	0.038	0.56	0.1
Laboratory dough with fungi static agent	0	0.014	0.51	0.1
	94	0.049	0.54	0.1
Commercial dough	0	0.021	1.87	0.1
	94	0.042	.....	0.1

[1] Milliequivalents of free fatty acid per g of dough fat.
[2] Total reducing substances (expressed as % glucose).
[3] Molds (thousands per g of dough).

static agent. This small increase could be attributed to spontaneous hydrolysis of dough fat and/or enzymatic activity due to low levels of flour lipases. Total reducing substances increased in all doughs during observation at 39° F and 19° F. At 39° F this increase occurred to about the same degree in the presence and absence of the fungistatic agent. Consequently molds appear not to be responsible for the increase in reducing substances. The rate at which reducing substances were liberated seemed dependent on dough storage temperature. In dough samples kept at 0° F (−18° C) no significant changes occurred during a 94-week period.

Pie doughs which were prepared from "shorts" and held at 39° F had developed excessive mold growth at the end of 2 weeks. Even though "shorts" are reported to have high levels of lipase activity compared to flour *(5)*, pie dough with shorts exhibited fat hydrolysis to about the same extent as the doughs with flour, during this test period.

These experiments indicate that fat hydrolysis and increases in total reducing substances occur in pie doughs held at low temperatures, but at temperatures of 19° F or lower, these changes occur at a very slow rate. The results with "shorts" also suggest that doughs prepared from flour fractions having marked variation in composition undergo these chemical changes to about the same degree of magnitude. Changes in doughs are so slow compared to those that can be expected in pie fillings *(8)* as to suggest they need be of little concern in commercial storage practice.

Acknowledgments

The authors are indebted to Mr. Henry Wright for the fatty acid determinations and to Mr. Waldo Maher for the determination of reducing substances.

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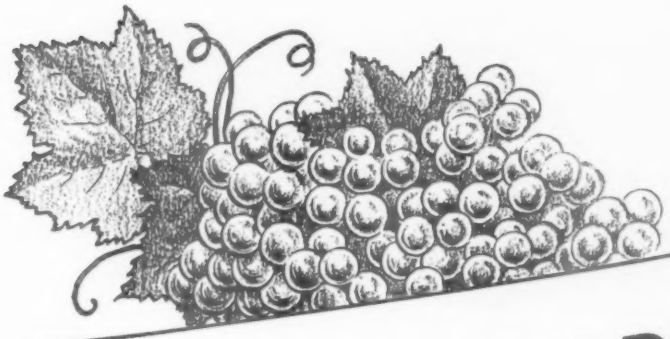

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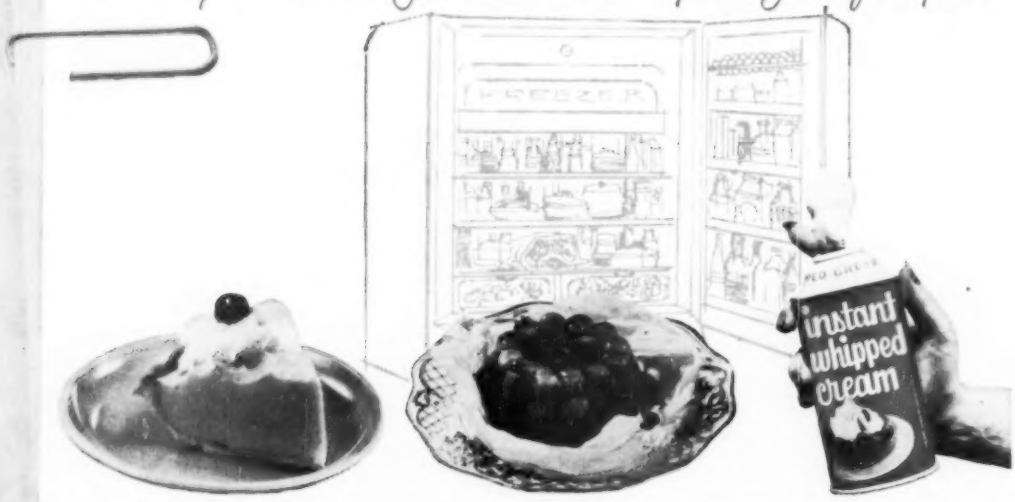

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Transistorized Bloom Gelometer

THE "BLOOM GELOMETER" has been in use for a number of years for gel strength measurement of gelatin and other colloidal gel systems *(3, 7)*. Many attempts have been made over the years to improve the precision and accuracy of the method. Some improved methods of gel strength measurement are the "universal gelometer" of Saxl *(8)*, "starch paste gelometers" *(1, 6)*, and improved models of the standard Bloom Gelometer *(2, 4)*. An excellent semimicro gelometer has recently been described *(5)*. In spite of these improvements, the standard Bloom gelometer in use today is essentially the same instrument originally described by O. T. Bloom *(3)*. Aside from its conversion from battery to 110V A. C. operation, its electrical circuitry has remained essentially unchanged. The schematic wiring diagram of a modern Bloom Gelometer is as shown in Figure 1. In its present form, the device has many defects. A major fault is that in spite of relay RL-1, a sizeable current flows through the silver plated contacts S-2. This causes burning and pitting at the contact surfaces which must be then frequently polished and the gap readjusted to exactly 4 mm. If the contacts are not properly cared for, loss of sensitivity, precision, and accuracy may result.

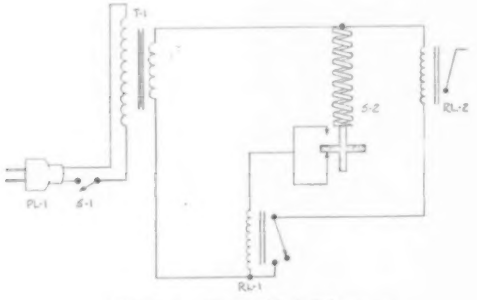

Figure 1. Unmodified Gelometer.

In this laboratory, it was decided to modify a gelometer by reducing the current passing through contacts S-2 to a negligible value. This was done by using a transistor amplifier circuit. Thus, once the contacts were polished and adjusted to 4 mm, they would not have to be adjusted for a long period of time. Not only would pitting be eliminated, but, even if the contacts became dirty through slow deposition of a film of dust, the extreme sensitivity of the transistor circuit would continue to activate relay RL-1 and chute RL-2 in the normal manner.

The "Fisher Model 30 Transistor Relay Amplifier" was tried and found to operate quite satisfactorily for this application. Its advantages were as follows:

(1) Line voltage (110V) operated
(2) Inexpensive (about $65)
(3) Very sensitive, the 4 transistor circuit operated even with a very poor contact (>50,000 ohms)
(4) The current in contacts S-2 was reduced from about 100 ma to about 0.1 ma
(5) With a few added parts, a commercial Bloom Gelometer could be converted to transistor operation in a short time.

CONSTRUCTION

A gelometer built according to Figure 1 was rewired by adding the wiring of Figure 2 indicated by the heavy lines. The light lines of Figure 2 is existing wiring which was left unchanged. If it was desired to have the modified gelometer function *only with the added external amplifier relay* (recommended), switch S-4 could have been omitted from the circuit and the gelometer wired to function as though the switch was permanently in the "up" position.

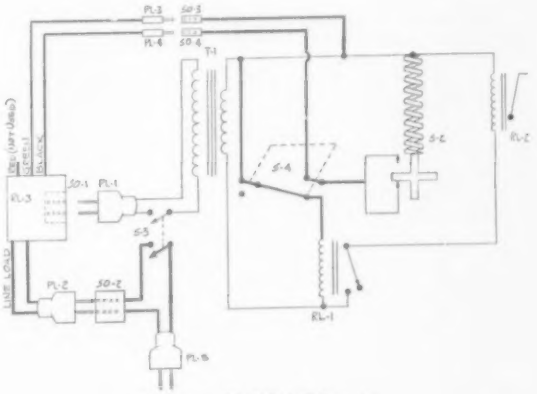

Figure 2. Modified Gelometer.

The only use for S-4 is to run tests comparing results with and without the transistor amplifier. When transistor relay is used, RL-3 must be set at "N C" and S-4 is in the "up" position; reversing both switches eliminates transistor portion of the circuit. "Delay" circuit is not used.

Conversion steps. (Refer to Figure 1 and Figure 2)

1. Remove S-1 and replace it with DPST switch S-3. Reconnect the wires to one side of S-3.
2. Mount socket SO-2 in the back of the gelometer.
3. Mount "banana" sockets SO-3 and SO-4 on the back of the gelometer.
4. Mount "External Gelometer" switch S-4 on the right side of the gelometer.
5. Remove the wires going from T-1 and RL-1 going to S-2 and reconnect to S-4, SO-3 and SO-4 as shown by the heavy lines in Figure 2.
6. Wire in SO-2, PL-5, and S-3 as shown.
7. Make two 1-foot leads and put a "banana plug" on the end of each. (PL-3 and PL-4). Connect to RL-3 (green and black terminals) and plug the "banana plugs" into SO-3 and SO-4.
8. Plug PL-1 into SO-1, the "normally on" socket of RL-3.
9. Plug PL-2 into SO-2 and plug PL-5 into 110 V receptacle outlet.
10. Check all wiring and make sure it conforms with Figure 2. The unit is now ready to operate with or without RL-3 in the circuit, as desired.

RESULTS

The results were quite satisfactory. The general "operator sensitivity" was increased. Sparking was

completely eliminated even when the gap was closely examined during operation in a pitch-black room. After 6 months of frequent routine operation, no burning, pitting or even darkening was noted on the contacts of S-2. Accuracy was not changed appreciably as shown by running gelatin gels on two gelometers, one unmodified and the other equipped with the transistorized relay.

In Table 1, the standard deviations among punches (for a single jar of gelatin gel) and among jars are given. About 50 samples were used for the study. Among "punches" on a single jar, a slight improvement is evident with the modified gelometer. However, among jars, a considerable improvement in precision (i.e. much less scattering of points) was obtained when the transistorized relay was used. Using a dummy Bloom device (which simulates a gel) to check accuracy and precision gave comparable results.

TABLE 1

Standard deviations among "punches" and among "jars" for an unmodified gelometer and a modified (transistorized) gelometer

Solution Number	Among punches, standard deviation		Among jars, standard deviation	
	Unmodified gelometer	Modified gelometer	Unmodified gelometer	Modified gelometer
1	1.0	0.6	1.3	1.2
2	1.6	1.3	2.7	1.9
3	2.3	1.8	4.2	1.7
4	2.3	2.7	6.7	3.3

For all cases, precision was generally at least as good with the relay as without. For many cases, a gain in precision was effected by use of the relay. An even greater gain could be expected for long range precision as no pitting would be gradually accumulated as the instrument was used.

Parts included on a Bloom Gelometer, as purchased

PL-1 Standard 110 V 2 prong plug
S-1 SPST Toggle Switch
S-2 Contact Disk and Points
T-1 Step Down Transformer
RL-1 SPDT Relay
RL-2 Magnetic Chute Release Relay

Additional parts required to convert for transistor relay use

PL-2, PL-5 Standard 110 V 2 prong plugs (PL-2 is a part of RL-3)
PL-3, PL-4 "banana" plugs
S-3 DPST Toggle switch. New main "on-off" switch
S-4 DPDT Toggle Switch. "External Gelometer" switch
RL-3 Fisher model 30 transistor relay (Catalogue No. 13-991-75)
SO-1 the "normally on" socket of RL-3
SO-2 110 V 2 prong socket
SO-3 SO-4 "Banana" sockets

RALPH E. SCHACHAT AND ANTHONY NACCI
Jell-O Division, Research Laboratories
General Foods Corp., Tarrytown, N. Y.

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The Effect of Several Silicones on Volume of Yellow Cakes[a, b]

It has been reported that baking failures of whole-egg cakes can result from traces of certain silicone compounds *(3)*. Sources of contamination suggested were ingredient packaging materials or shortenings *(1)*. Eggs have been made a possible source by the use of a silicone as a constituent in an egg shell sealing mixture *(4)*. In addition, certain silicones with antifoaming properties may prove useful in egg washing compounds. Such contamination of the egg shell with the particular silicones that affect cake volume and texture could result in a sufficient amount getting into the batter to result in baking failures.

The purpose of this study was to determine the effect of several silicones that are or might be used on shell eggs on the volume and texture of yellow cakes.

EXPERIMENTAL PROCEDURE

The effect of 7 silicone compounds on a complete yellow cake mix was studied in 2 separate baking laboratories. Each of the 7 compounds was used at 3 different levels, namely, 0.1 ppm, 1.0 ppm and 10 ppm. There were three replications in each laboratory. The silicone compounds tested were all obtained from Dow Chemical Company and were identified as follows: DC 200—20 centistokes; DC 200—70 centistokes; DC 200—350 centistokes; DC 200—60,000 centistokes; DC 555; AF Emulsion; and Antifoam A Compound.

Silicones were weighed by subtraction and blended with 100 ml of water. The amount of emulsion required to provide 0.1, 1.0, or 10.0 ppm was calculated and included in the first 40-ml portion of water used in preparing a batter.

In laboratory 2 a second series of tests was conducted using the same treatments with a popular brand of cake mix requiring the use of fresh eggs. Silicones were weighed by difference into 100 g of homogenized whole egg. The calculated amount of egg and silicone was then incorporated as part of the egg used in each batter. Cake volume was measured by using a modification of the Bennington and Geddes *(2)* seed displacement procedure.

RESULTS AND DISCUSSION

Results of the first series of tests are summarized in Table 1. Analyses of these data revealed statistically significant ($P<.01$) differences between laboratories, silicones, and levels of silicones. There were little if any deleterious effects of any of the silicones tested at the 0.1 or 1.0 ppm levels. At the 10 ppm level all silicones with the exception of DC-555 resulted in at least a tendency to lowering of volumes.

A second series of tests was conducted using cake mix with fresh eggs. The effects of the several silicones on this type cake mix are very similar to effects noted on the complete mix. The variance attributable to silicones was significant at the five per cent level of probability. Differences between levels of silicones were significant at the one per cent level.

Results obtained in these studies were not as dramatic as reported previously *(1, 3)* but they do confirm these observations. Some silicones could result in baking failures with yellow cakes. The silicone proposed *(4)* as a constituent for a mixture to coat shell eggs, DC-555, had no apparent effect on cake volume. The use of antifoam silicones in egg cleaning compounds should be carefully checked as at least one of this type of silicone did reduce volume of cakes, when the silicone was introduced into the cake batter.

TABLE 1

Mean volume of yellow cakes baked in each of two laboratories as influenced by type and amount of silicone present in the batter of a "complete" cake mix

Amount of silicone (ppm)		0.1	1.0	10.0
Type of silicone	Laboratory	ml	ml	ml
DC-200-20[1]	1	910	927	887
	2	937	940	927
DC-200-70	1	923	907	863
	2	943	960	903
DC-200-350	1	937	877	850
	2	923	923	887
DC-200-60,000	1	930	930	920
	2	963	960	820
DC 555	1	913	913	927
	2	953	963	920
AF emulsion	1	917	913	873
	2	920	943	903
Antifoam A	1	907	880	827
	2	933	947	857
Controls—no silicone	1	913		
	2	933		

[1] Number following DC 200 is viscosity of silicone oil in centistokes.

SUMMARY

The effect of seven silicone oils on yellow cakes prepared with institutional and consumer-type cake mixes was determined. Of the silicones tested, none resulted in serious diminution of cake volume when included in the batter at 0.1 or 1.0 ppm. At a 10 ppm level, some of the silicone oils resulted in a reduction in volume of yellow cakes by as much as 20%. Others of the silicones used had no significant effect on volume of yellow cakes even when 10 ppm of the silicone was incorporated into the batter.

Acknowledgment

The authors appreciated the assistance of the two technicians Mrs. Carolyn Kelpien and Mrs. Julia Frohreich for their assistance in the conduct of the research.

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Grace Bennett
Purdue University,
Lafayette, Indiana

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[a] Journal paper No. 1433 Purdue Agricultural Experiment Station, Lafayette, Indiana.

[b] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 18, 1959.

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IFT News

MOHAWK VALLEY

"The Essential Oils of Africa," a film by Dr. Ernest Guenther, Vice President and Technical Director of Fritzsche Brothers, Inc. was presented at the regular meeting on November 19, 1959, held at Little Falls Country Club, New York. Mr. Robert J. Eiserle of Fritzsche's technical staff introduced the film and answered questions.

—Glenn H. Olmstead

MARYLAND

The Maryland Section held their monthly meeting at the Stafford Hotel in Baltimore on November 20, 1959.

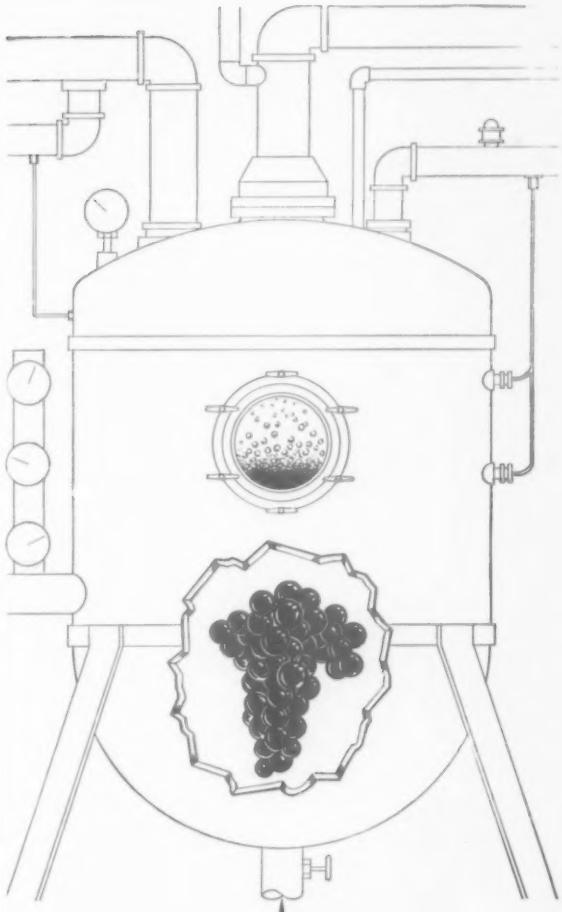
Cocktails were served before dinner, courtesy of National Can Corporation.

The Section had an excellent attendance of 52 members to hear Dr. L. E. Clifcorn, Manager, Central Division, Research Department, National Can Corporation who spoke on "The Problem of Food Packages Under the Food Additives Amendment."

The Food Additive Amendment, now slightly over a year old, has caused considerable confusion in the food packaging industry with regard to where the responsibility for safety to the public lies and how packing materials should be cleared with the Commissioner of Foods and Drugs. By act of Congress, according to the Amendment if there is no significant extractability or if the material has been given prior approval by a government agency, or if in the eyes of qualified experts the material is generally regarded as safe or if by common usage over a long period of time the material has been established as safe—then the packaging material is not subject to the Food Additives Amendment and no further steps need to be taken.

When there is a significant extractability the identity of the extractables in the food must be determined. If these are not hazardous to the consumer, clearance may be obtained.

With regard to the metal container, plain or enameled, customers are demanding statements from the can suppliers guaranteeing safety of the containers. One legal interpretation is that they are not subject to the Amendment since they meet all the criteria of exemption in section 201 (2) of the Act. Nevertheless a statement of their safety is desirable from the Commissioner of Foods and Drugs. In this regard the Can Manufacturers Institute is applying for statements for both the plain and enameled can from the Commissioner of Foods and Drugs. Since these requests are backed by a large amount of work on the public health safety of the metal containers—there is every confidence that the response will be favorable.



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The Maryland Section held their annual ladies' night meeting at the Stafford Hotel on December 11, 1959.

Festivities opened at 6:30 P.M. with a cocktail hour followed by a highly successful dinner meeting.

The following officers were elected for the 1960 term:

Chairman—Leonard F. Gieseker.
Vice Chairman—Warren E. Anderson.
Secretary—Richard J. LeForge.
Executive Committee—William F. Corse.
Counselor—Dr. Amihud Kramer.

The outgoing Chairman, Mr. Irving Cohen, delivered a lively talk on the subject "Rigged Science-Fads and Falacies."

Door prizes were then distributed to the ladies and the year was brought to a close by a most entertaining evening.

—*Warren E. Anderson*

AMES

The fall meeting of the Ames Section was held at the Memorial Union, Iowa State University, Ames, Iowa, on October 23, 1959. Mr. Ray Wakefield, National IFT President and Director of Research at Gerber Products Co. made the presentation of the plaque accompanying Gerber Undergraduate Scholarship Award to William J. Coffin. The afternoon program was devoted to talks on waste disposal:

"What's In It For Me?" (A general introduction to the topic of waste disposal.) Harold E. Babbitt, Visiting Professor of Civil Engineering.

"Waste Abatement in Iowa Dairy and Meat Processing Industry." H. Sidwell Smith, Stanley Engineering Company, Muscatine, Ia.

At the business meeting the following officers were elected for 1960:

Chairman: Mr. Edward Wardrip, Clinton Corn Processing Co., Clinton, Iowa.

Chairman-Elect: Dr. William Marion, Poultry Department, Iowa State University, Ames, Iowa.

Secretary-Treasurer: Dr. Frances Carlin, Food Processing Lab, Iowa State University, Ames, Iowa.

Councilor: Dr. William Brown, Morrell & Co., Ottumwa, Iowa.

Alternate Councilor: Dr. Harry Snyder, Food Processing Lab, Iowa State University, Ames, Iowa.

—*Frances Carlin*

WISCONSIN

The Wisconsin Section closed its Fall activities schedule with meetings at Waukesha (October 30) and Milwaukee (November 20). Host at the Waukesha gathering was Dairyland Food Laboratories, Incorporated. Following a tour of the firm's enzyme extraction and purification facilities, a demonstration of cheddar cheese manufacturing was viewed by 70 section members. Dr. John Nelson of the Dairyland staff later spoke to the group on the role of enzymes in the development of food flavors.

About 50 members and guests attended the Milwaukee meeting which began with a tour of the Jones Island Sewerage Disposal Plant, the first major installation of its kind in America. The evening's speaker was Dr. Bernard Wolnak, Midwest Laboratories, who discussed the production of Vitamin B_{12} from Milorganite. Annual election returns were announced with the following officers for 1960:

Chairman—Oswald Freund, Red Star Yeast and Products Co.; Chairman elect—Russell Maas, Oscar Mayer Co.; Secretary-Treasurer—Katherine Powers, Ripon Foods; Councilor—Ara Call, Western Condensing; Member at Large—John Nelson, Dairyland Food Laboratories.

AK-SAR-BEN

The Ak-Sar-Ben Section of the Institute of Food Technologists in co-operation with the College of Adult Education of the University of Omaha has completed its series of twelve lectures pertaining to Food Processing and Technology. This was the first class of this type to be offered in the Omaha area, and was

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the result of months of planning by the local officers of the IFT and officials of Omaha University. The classes began September 24th and ran through December 17th, 1959. Experts from the food industry, government, and allied fields conducted the classes.

The twelve lectures covered a wide field including the control of micro-organisms, enzymes in foods and food processing, flavors and additives, sanitary processing equipment, handling, packing and marketing. Omaha, one of the largest centers of food processing, gave the course a warm reception with approximately 45 from this area enrolled in the course.

—Ben C. Sulskis

N. CALIFORNIA

Three highlights climaxed the annual December all-day meeting at the Claremont Hotel in Berkeley, California. The attendance was good and everyone was enthusiastic over the success of the meetings.

Dr. Max Kleiber, originally from Switzerland, now Professor of Animal Husbandry at the University of California, Davis, spoke to us on "Growth of Population and Food Supply." Here are a few excerpts:

In primitive times no one had to accept starvation. The skill of the hunter and the availability of edible fruits and roots prevented such a fate. Tribal wars were derived from the natural struggle for survival and the side that had a better type or quality of food to eat was the one that conquered. Over the long centuries men learned to cultivate gardens and to store the non-perishables for the lean years. However, today, despite great advances only one-fifth of the human population has enough to eat; the other four-fifths starve!

The problem of survival in relation to the food supply was first considered mathematically by Malthus, who held that population increases geometrically, but food increases in arithmetic progression. Only a century ago it was firmly believed that poverty and misery are the natural punishments for not thinking ahead and saving.

Today, how do we stand? In America we are plagued with too much food rather than a scarcity. Starvation in the world today is due to distribution and economy factors and not to any failure in the ability to produce food.

In the future the population growth vs. food supply question will have to be studied mathematically and with greater precision than before. But we can learn from what has happened in the past something of the future prospect. We have to bear in mind the fact that although there is plenty of food today—there is a limit: the amount of carbon on earth. There is also the energy requirement: how much fuel is needed to keep us going? We shall need to maintain the highest efficiency of plant and animal production. We shall need to consider how best to utilize the sun's energy for producing food and other products.

At the dinner meeting as the second highlight the new officers for 1960 were introduced as: Chairman—Charles T. Townsend, National Canners Assoc., Berkeley; Vice Chairman—Hans Lineweaver, U.S.D.A., WRRL, Albany; Executive Secretary—Dave Eolkin, Gerber Products, Oakland; Membership Secretary—Edward L. Meyers, Continental Can Co., Hazel Atlas Glass Div., Hayward; Treasurer—Charles B. Rasmussen, Wm. J. Stange Co., Oakland.

Executive Committee—John E. Brekke, U.S.D.A., WRRL, Albany; Robert J. Marsh, Canners League of California, San Francisco.

Nominating Committee—Adolph R. Asti, S&W Fine Foods, Inc., Redwood City; Hugh T. Griswold, Owens Illinois Glass Co., San Francisco; Norman E. Liles, Tri-Valley Canning Assn., San Jose; Gordon Mackinney, University of California, Berkeley; Alan C. Richardson, California Packing Corp., San Francisco.

The third highlight of the evening was the awarding of the golf trophy to Lloyd R. Van Auken, Gerber, for low net blind bogey. The low gross award went to Donald S. Brownlee of Continental Can Co., Hayward, and the hole-in-one award was given to Gary Douglas.

At the regular February 18 meeting we are going to be privileged to hear Mr. Edwin S. Doyle speak on Sanitation Administration.

—Shirley V. Noland

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1959-1960	
February 23-24	Eighth Annual National Dairy Engineering Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
March 3-4	Second Better Foods for Better Nutrition Conference, Center for Continuing Education, University of Georgia, Athens, Georgia
March 11-12	Eighth Annual Food Technology Short Course, "Impact of Convenience Foods," Memorial Student Union, University of Missouri. Sponsored jointly by the St. Louis and Kansas City Sections of IFT with the College of Agriculture, Columbia, Missouri
April 19-21	Research and Development Associates 14th Annual Meeting, Congress Hotel, Chicago, Illinois
1960	
May 15-19	**Twentieth Annual Meeting of the Institute of Food Technologists, Fairmont Hotel and Masonic Temple, San Francisco, California**
May 19 to May 25 or 29	IFT Pacific Rim Conference, Princess Kaiulani Hotel, Honolulu, Hawaii
June 8-10	The 3rd Symposium on Gas Chromatography, Assembly Rooms, Edinburgh, Scotland
1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 10–14	**Twenty-second Annual Meeting of the Institute of Food Technologists, Fontainebleau Hotel, Eden Roc Hotel, Miami Beach, Florida**
1963	
May 19–23	**Twenty-third Annual Meeting of the Institute of Food Technologists, Pantlind Hotel, Civic Auditorium, Grand Rapids, Michigan**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

Literature

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY[a]

Commodities

The conching of chocolate; a survey of published information. L. E. Campbell. Leatherhead, Surrey, England, 1959. 12 p. (British Food Manufacturing Industries Research Association. Scientific and technical surveys, no. 35.) pap. Done at the request of the Cocoa and Chocolate panel.

Marketing costs and margins for selected lots of Wisconsin cheddar cheese. Hugh L. Cook and J. Kenneth Little. Madison, Wisc., 1959. 46 p. (Wisconsin Agricultural Experiment Station. Research bulletin 210.) pap. apply.

1960 potato handbook, potato processing issue, v. 5. New Brunswick, N. J., Potato Association of America, 1959. 80 p. pap. $2.00.

Food Technology

Food; America's biggest business. Pauline Arnold and Percival White. New York, Holiday House, 1959. 338 p. $3.95. A popular treatment covering modern angles of food production.

Research for better quality in frozen foods. Washington, 1959 . 6 p. (U. S. D. A. Agricultural Research Service. ARS 74-13.) pap. apply.

Nutrition

Protein and amino acid nutrition. Anthony A. Albanese, ed. New York, Academic Press, 1959. 604 p. $16.00.

Chemical Aspects

Advances in catalysis and related subjects, v. 11. D. P. Eley and others, eds. New York, Academic Press, 1959. 384 p. $12.50.

Appraisal of the safety of chemicals in foods, drugs and cosmetics. Staff, Division of Pharmacology, Food and Drug Administration. Austin 1, Texas, Association of Food and Drug Officials of the United States, Texas State Department of Health, 1959. 107 p. pap. Article p. 97+ by Dr. A. J. Lehman is "The interpretative problems in evaluating the safety of food additives."

Heterocyclic chemistry, an introduction. Adrien Albert. Fairlawn, N. J. Essential Books, 1959. 424 p. $9.00. Distributed by Oxford University Press, New York.

[a] Material for this list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

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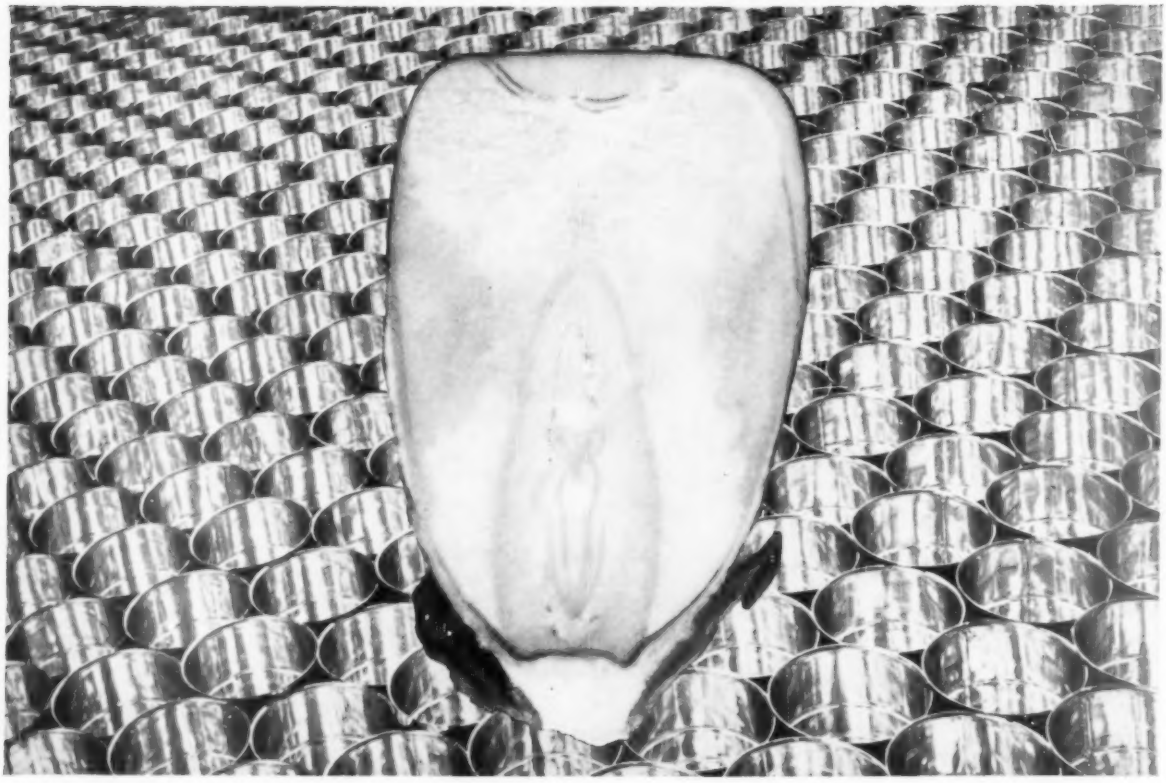

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Organic syntheses, an annual publication of satisfactory methods for the preparation of organic chemicals, v. 39. New York, Wiley, 1959. 121 p. $4.00. Another volume in the long series that cumulates each 10 volumes.

Biological Aspects

Advances in enzymology, v. 21. F. F. Nord, ed. New York, Interscience, 1959. 528 p. $12.50.

International review of cytology, v. 8. G. H. Bourne and J. F. Danielli, eds. New York, Academic Press, 1959. 541 p. $13.00.

Laboratory manual for food microbiology, 3d ed. W. C. Frazier and E. M. Foster. Minneapolis, Burgess, 1959. pap. price not given.

Miscellaneous

American men of science; 10th ed. Physical and biological sciences, A-E. Jacques Cattell, ed. Tempe, Ariz., Jacques Cattell Press, Annex 15, Arizona State University, 1959. 1100 p. $25.50. This standard listing of scientists is in a new volume arrangement but with the physical and biological scientists in one alphabet.

The analysis of variance. Henry Scheffé. New York, John Wiley and Sons, 1959. 477 p. $14.00.

History of the American Dietetic Association. Mary I. Barber, ed. Philadelphia, Lippincott, 1959. 328 p. $6.00.

ABSTRACTS

General Foods Research Center
Selected by H. A. Campbell

ANALYTICAL METHODS

Detection of enzymes by paper chromatography.

PANEK, A. (School of Chemistry, Rio de Janeiro, Brazil). *J. Chromatography 2*, 566–8 (1959).

The prepn. and identification of enzymes produced by microorganisms generally involves very accurate techniques and special apps. The aim of this research was to obtain enzymes of just sufficient purity to enable their activity to be tested by paper chromatography. The detection of aspartase, transaminase, glucose oxidase, maltase and amylase by paper chromatography is discussed.

Separation of fatty-esters by gas chromatography.

JART, A. *Fette, Seifen, Anstrichmittel 61*, 541–6 (1959).

With the help of gas chromatography the author analyzes various fats qualitatively, as well as quantitatively, by first converting the fatty acids to their methyl esters. After giving a full description of the app. used, the exptl. procedure and the results are discussed.

Chlorinated solvents for determination of crude fat in feeds and meat products.

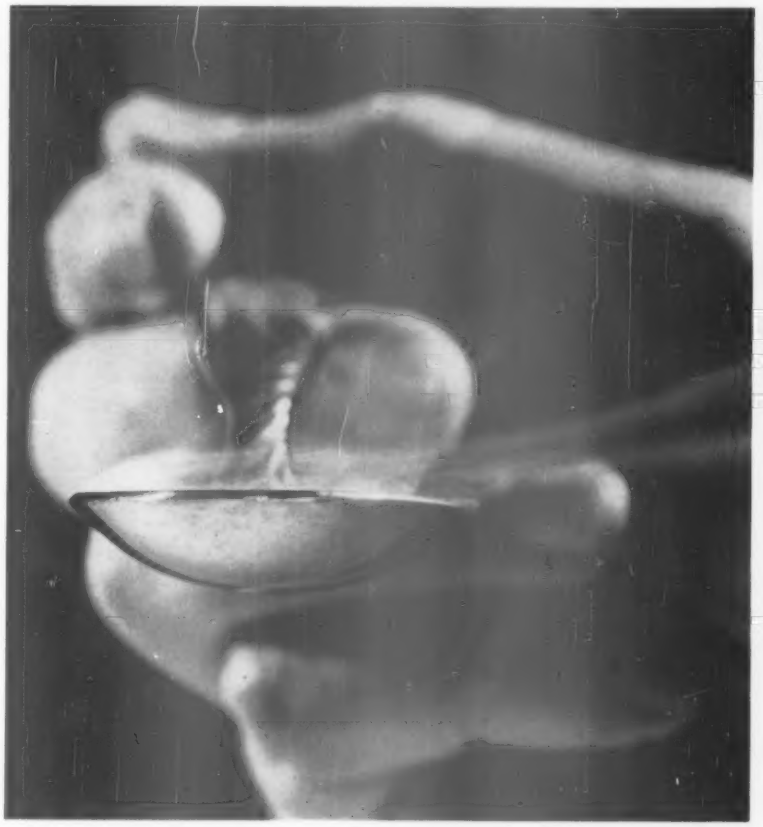
SHERMAN, I. R. (Sherman Research Labs., Toledo, Ohio). *J. Assoc. Offic. Agr. Chemists 42*, 646–7 (1959).

Chlorinated solvents, i.e. carbon tetrachloride, trichloroethane, and perchloroethylene, ext. fat more completely from feeds and meat products than ethyl ether, and do not require previous drying of the sample.

An indicator tube for the determination of trichloroethylene in air.

GAGE, J. C. (Industrial Hygiene Research Labs., Engl.). *Analyst 84*, 509–15 (1959).

The air sample is drawn through 2 tubes, which are joined in series immediately before the test. The first tube contains a layer of silica gel impregnated with $KMnO_4$ and *o*-phosphoric acid; the second tube contains silica gel impregnated with *o*-tolidine HCl and serves to measure chlorine liberated by the first tube.



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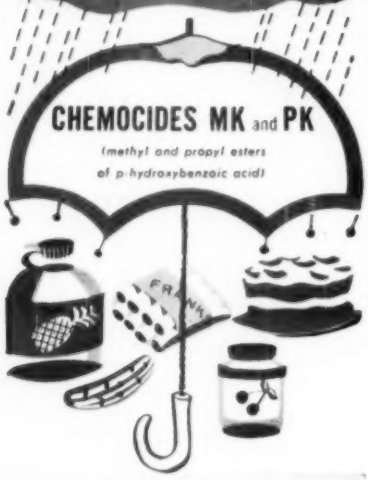

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BIOLOGICAL SCIENCES

Biochemistry

Protein depletion and amino acid requirement in the growing chicken.

FISHER, H., GRIMINGER, P. AND LEVEILLE, G. A. (Rutgers Univ., New Brunswick, N. J.). *J. Nutrition 69*, 117–20 (1959).

The methionine and lysine requirement of normal and protein-depleted chicks was detd. in diets contg. 20% of protein. For both amino acids a higher absolute requirement could be demonstrated for the depleted birds. Data are presented which explain these findings on the basis of a greater protein requirement for the depleted chicks.

Conversion of serum proteins into tissue protein.

FLEISCHER, S., LIETZE, A., ET AL. (Indiana Univ., Bloomington). *Proc. Soc. Exptl. Biol. Med. 101*, 860–3 (1959).

Incorporation of S^{35} and C^{14} from injected doubly-labeled rat serum albumin or globulin into the tissue proteins of rats was investigated. The ratio S^{35}/C^{14} in tissue proteins varies very little during 9 days after injection of the doubly labeled serum proteins. Results indicate that conversion of plasma proteins into tissue proteins involves breakdown to amino acids or very small peptide fragments. There is no indication of the transfer of large peptide fragments from plasma protein to tissue protein molecules.

Reactions of proteins with gossypol.

LYMAN, C. M., BALIGA, B. P. AND SLAY, M. W. (Texas Agr. Expt. Sta., College Station). *Arch. Biochem. Biophys. 84*, 486–97 (1959).

When gossypol combines with blood albumin or with cottonseed protein, the reaction is with the free ε-amino groups of lysine. The ratio of moles of free lysine ε-amino groups which disappear to moles of gossypol combined with protein varies according to the conditions of the test. Under certain conditions, this ratio is 2, indicating that both of the reactive carbonyl groups of gossypol are linked to lysine. The data suggest that gossypol cross-links protein molecules to form dimers, trimers, tetramers, etc.

A simple method for the assay of small amounts of antidiuretic hormone.

HUNTEE, J., KALANT, H. AND OGILVIE, J. C. (Defence Research Medical Labs., Toronto). *Can. J. Biochem. Physiol. 37*, 1215–25 (1959).

A reliable, sensitive, and simple technique is described for the assay of antidiuretic hormone in amts. between 25 and 130 μ units. Specially designed cannulae, implanted on the day before the assay, provide unimpaired access to the stomach and bladder, permitting the maintenance of hydration and continuous urine collection without disturbance of the animal. Material to be assayed is injected intravenously. Water load is maintained by manual injection of 0.5-ml. quantities of 0.05% NaCl soln. at intervals dependent upon the rate of urine production. A useful index for expression of the response is described, which is related to both the intensity and the duration of antidiuresis.

Isolation of a respiratory inhibitor from alfalfa.

SHAW, R. A. AND JACKSON, H. D. (Purdue Univ., Lafayette, Ind.). *Arch. Biochem. Biophys. 84*, 405–10 (1959).

A method is presented for the isolation of a respiratory inhibitor from an alfalfa forage which caused bloat in grazing cattle. Solvents were used to ext. the crude respiratory inhibitor, and ion-exchange chromatography sepd. it from an anticholinesterase constituent of the forage. Carbon-column chromatography afforded purification of the respiratory inhibitor, which was eluted with methanol and then further purified by pptn. with cholesterol.

Identification of a growth inhibitor from extracts of dormant peach flower buds.

HENDERSHOTT, C. H. AND WALKER, D. R. (North Carolina State Coll., Raleigh). *Science 130*, 798–800 (1959).

A growth inhibitor in dormant peach flower buds was identified as naringenin (5,7,4′ trihydroxyflavanone) from infrared and ultraviolet spectra, through detn. of melting point, through paper chromatography, and from activity in the bioassay test.

Microbiology

Method for rupturing large quantities of microorganisms.

GARVER, J. C. AND EPSTEIN, R. L. (Univ. of Wisconsin, Madison). *Appl. Microbiol. 7*, 318–19 (1959).

The usual techniques for the mechanical rupturing of yeast and bacterial cells, are unsuitable for breaking larger quantities of cells required in many investigations. An attempt was undertaken to rupture cells in a cell-glass bead slurry under conditions where high shearing forces could be obtained using the Eppenbach colloid mill Model ZV-6, which operates at 8000 rpm. The influence of bead concn., mill setting, and time on cell breakage was studied. Optimal breakage was obtained with 60 ml. of beads/100 ml. of suspension and with a mill setting of 0.030 in.

Nutrition

The mode of absorption of vitamin A across the intestine of rats.

MAHADEVAN, S., KRISHNAMURTHY, S. AND GANGULY, J. (Indian Inst. of Sci., Bangalore). *Arch. Biochem. Biophys. 83*, 371–5 (1959).

Irrespective of the form fed, vitamin A was present as both ester and alcohol in the contents, mucosae, muscles, and mesentery of the small intestine and in the blood of rats dosed with oily or colloidal solns. of vitamin A alcohol, acetate or palmitate and sacrificed 60–90 min. later.

Corpuscular resorption of milk-fat and fine fat-emulsions.

HAUBOLD, H. *Fette, Seifen, Anstrichmittel 61*, 669–72 (1959).

A series of expts. have been carried out to study the resorption of various edible fats. The microscopic picture taken during the passage of the fat dyed with Sudan III through the walls of the small intestinal villus shows that the resorption passage of the natural emulsion of butter is predominantly corpuscular over the lymphatic system. The fats which are not taken in the form of emulsions are emulsified in small intestine under the influence of gall and pancreas and partly broken up on the intestinal walls under the action of ferments. The author establishes further that the resorption of fat-emulsions starts in the mouth through the mucous membrane. It is shown that the resorption during the early childhood takes place only over the lymphatic system.

Diet and atherosclerosis. Variations on a theme.

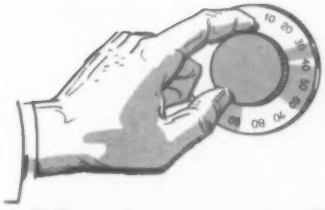
POLLAK, O. J. (Dover Med. Research Center, Del.). *Am. J. Clin. Nutrition 7*, 502–7 (1959).

The Japanese eat dry rice and green-leaf-tea sherbet and consume what might be considered an "antiatherogenic" diet. On the other hand, the diet in Thailand is rich in fat and cholesterol and contains little linoleic acid and few other unsatd. fatty acids. In spite of the fact that the Thailand diet might be considered "atherogenic" there is a very low incidence of atherosclerosis there. Conversely atherosclerosis is rather common in Japan.

Amino acid balance and imbalance. II. Dietary level of protein and lysine requirement.

MUNAVER, S. M. AND HARPER, A. E. (Univ. of Wisconsin, Madison). *J. Nutrition 69*, 58–64 (1959).

Poor amino acid balance and high lipid content of wheat gluten increase the lysine requirement of the rat for



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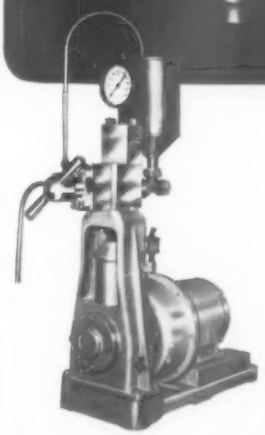

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maximum growth when this protein is fed at high levels as the sole source of lysine in the diet.

Amino acid deficiencies in casein.

ANON. *Nutrition Revs. 17*, 282–4 (1959).

The order of growth limiting amino acids in casein was studied. It was concluded that the amino acids in a diet contg. a low level of casein as the only source of protein, becomes limiting in the following order: methionine; threonine; tryptophan, isoleucine, histidine; valine and phenylalanine; lysine; non-essential amino acids. This differs from the calcd. order, which has tryptophan as the second limiting amino acid. The conclusion of the author is that this difference is probably due to the fact that the estd. requirements for the rat may be too high.

Comparative study of human milk and a soya bean formula in promoting growth and nitrogen retention by infants.

FOMON, S. (State Univ. of Iowa, Iowa City). *Pediatrics 24*, 577–84 (1959).

1.7 g./kg./day of protein from a formula of soya bean is considered enough to prevent appearance of gross evidences of malnutrition in infants weaned near the end of the first year of life since their wt. gain while fed this protein was normal, and retentions of N were at least as great as those of normal full-term infants fed human milk.

Toxicology

Beneficial effects of alfalfa meal and other bulk-containing or bulk forming materials on symptoms of Tween 60 toxicity in the immature mouse.

ERSHOFF, B. H. AND HERNANDEZ, H. J. (Univ. of Southern California, Los Angeles). *J. Nutrition 69*, 172–8 (1959).

Immature mice fed a highly purified low-fiber diet contg. 7.5% of polyoxyethylene (20) sorbitan monostearate (Tween 60) exhibited retardation in growth, diarrhea, an unthrifty appearance and decreased survival. These effects were largely counteracted by the concurrent administration of alfalfa meal, or dehydrated rye grass, orchard grass, wheat grass or fescue grass at a 10% level in the diet or carrageenin, sodium alginate or agar at a 5% level of feeding. Cellulose in the form of Solka Floc or cellophane spangles when fed at a 5 or 10% level, yeast at a 10% level and carboxymethylcellulose, celite and calcium silicate at a 5% level of supplementation prevented diarrhea and promoted survival but were not as active as the substances indicated above in counteracting the retardation in growth.

INDUSTRY NEWS

The Carver Foundation announces that **Graduate Research Fellowships** for 1960-61 are available for research and graduate study toward the Master of Science degrees in chemistry, agronomy, and foods and nutrition. Special areas in which research is conducted include organic chemistry, physical chemistry, plant physiology, nutrition, food technology and isotope technology. These fellowships are available to students with high scholastic records, who have received the Bachelor of Science degree from an accredited college and who show promise of research ability. Stipends range from $1500 to $1800 annually. Fellowship applications are acceptable immediately. Address requests for further information and application blanks to: The Director, The Carver Foundation, Box 188, Tuskegee Institute, Alabama.

PERSONNEL

Since September 1, 1959, **Dr. Charles R. Stumbo** has been established as a Consultant in Food Preservation and Food Plant Sanitation with headquarters at Overbrook, Kansas, Route 2. After taking his doctorate in Bacteriology, 1941, at Kansas State College, he spent twenty-two years in government, college and industrial work. He has been affiliated with Kansas State College (now Kansas State University) South Dakota State College, U. S. Department of Agriculture, John Morrell & Company, Michigan Department of Health, Michigan State College (now Michigan State University), Owens-Illinois Glass Company, Food Machinery & Chemical Corporation, Washington State College, and H. J. Heinz Company.

C. R. Stumbo

A member of the Institute of Food Technologists and Society of American Bacteriologists (professional), he has published widely in the professional journals, e.g. Food Technology, Food Research, Agricultural Research, and Industrial and Engineering Chemistry. He is a former Associate Editor of Food Technology and of Food Research.

His current consulting interests are: food preservation (food preservatives and heat processing); food plant sanitation; animal growth stimulants (antibiotic, etc.); nutrition (human through improvement in preserved foods—animal through feed additives).

Keith A. Fitch has been promoted to the position of Manager, Institutional Division, Klenzade Products, Inc., according to announcement made by C. B. Shogren, President of that company at Beloit, Wisconsin. Mr. Fitch joined the company in 1958 as Sales Director for the Institutional Division. This new move is a further step in the expansion of institutional programs and sales on the part of Klenzade. Mr. Fitch is a registered professional engineer and registered professional sanitarian. Before joining Klenzade, he had extensive experience in sanitation, including nine years as a sanitation consultant to institutions and industry, industrial staff work, and service with the U. S. Food & Drug Administration. He is a veteran of World War II and a Colonel in the Air Force Reserve.

K. A. Fitch

IN MEMORIAM

It is with great sorrow that we announce the sudden death of Mynard W. Bessert, of the Research Department of Oscar Mayer & Co., on Wednesday, December 16, 1959. Graduated from the University of Wisconsin with a degree in chemistry, Mr. Bessert worked at Patrick Cudahy Co., Milwaukee, from 1932 to 1946 and for the past 13 years at Oscar Mayer & Co., Madison. During his last eight years he was Chief of Flavor Evaluation in the Research Department. He was a charter member of the Institute of Food Technologists, both National and Wisconsin sections, and a member of various civic organizations in Madison.

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SEASONING SPECIALIST — Food Chemist—Background of 12 years experience includes spices, seasonings, flavor matching, research, patents, and original development on several nationally distributed specialties. REPLY BOX 757, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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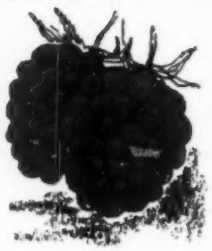

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